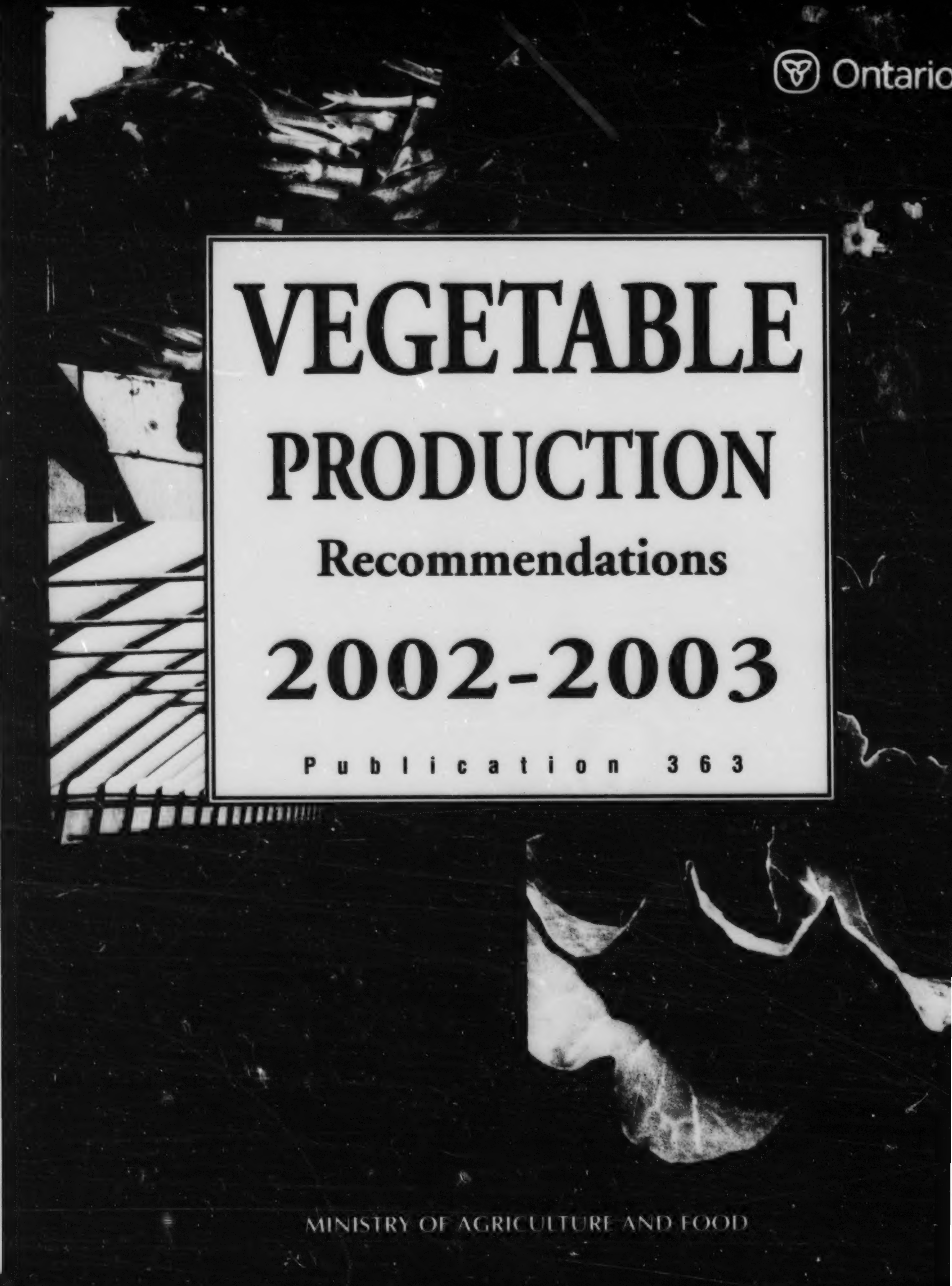


Ontario

# VEGETABLE PRODUCTION

## Recommendations

## 2002-2003

Publication 363

MINISTRY OF AGRICULTURE AND FOOD

**Recycle old editions** of this publication. Each year the appropriate working group of the Ontario Pest Management Research and Services Committee reviews the pesticides listed in this publication. To the best knowledge of the committee, at the time of printing, all of these pesticides were:

- federally registered
- reviewed by the Ontario Pesticides Advisory Committee (OPAC)
- classified by the Ministry of the Environment as of November 2001.

**The information in this publication is general information only.** By printing this publication, the Ministry of Agriclulture and Food does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

**The pesticide product label is a legal document. It is against the law to use the product in any other way.**
**You must also use all pesticides in accordance with the *Pesticides Act* and Regulation 914, administered by the Ontario Ministry of the Environment.**

In this publication, most recommendations list several pesticides that can be used for each pest discussed. In general the least hazardous materials and those pesticides that pesticide applicators have used satisfactorily for years are listed first. More toxic pesticides and/or newer ones with less practical grower experience follow.

This publication lists a number of brand names of pesticides. This is for your convenience only. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

**Consult each product label for specific information** such as compatibility with other materials and the effect of environmental conditions. Weather and other factors influence the effectiveness of pesticides and the likelihood of crop injury.

**Health Canada has established maximum residue limits (MRLs) for pesticides**. Processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market as to which restrictions or limitations apply. Keep accurate and up-to-date records on pesticide use in each crop.

## Federal Registration of Pesticide Products

The Pest Management Regulatory Agency (PMRA) of Health Canada grants registration following an evaluation of scientific data to ensure that the product has merit and value; and the human health and environmental risks associated with its proposed use are acceptable.

1. **Full Registration**
   Pesticide registrations are normally granted for a period of five years, subject to renewal.
2. **Temporary Registration**
   Temporary registration may be granted for a period not to exceed one year, where the registrant agrees to produce additional scientific or technical information, or the pesticide is used for emergency control of a serious pest outbreak.

## Supplemental Labels

**You MUST obtain a supplemental label and follow all the label directions when PMRA approves new uses for a registered pesticide that do not appear on the current label.**

Examples of when you must use a supplemental label include:

- **Temporary Registrations for Emergency Use**
- **Minor Use Label Expansion** (new label statements for crops that do not already appear on that product label).

You can obtain a copy of a supplemental label from the pesticide manufacturer or pesticide vendor, the grower association that sponsored the emergency registration or minor use, from OMAF or PMRA's Pest Management Information Service.

For more information on the federal registration status check the PMRA Web site at *www.hc-sc.gc.ca/pmra-arla* or call **1-800-267-6315.**

## Regulation of Pesticides in Ontario

### Classification of Pesticides into "Schedules"

The Ministry of the Environment classifies all pesticide products into one of six schedules, based on the potential hazards that product may have for human health and the environment. For up-to-date information on the regulatory status of any pesticide check the Ontario Pesticides Advisory Committee Web site at *www.opac.gov.on.ca* or call (416) 314-9230/ fax (416) 314-9237.

### Licensing and Certification Requirements for Pesticide Users

**You must be a certified grower or licensed exterminator to buy and use Schedule 1, 2 and 5 pesticides.**

### Requirements for Growers and their Assistants

Growers must be certified through the **Grower Pesticide Safety Course** to buy and use Schedules 1, 2 or 5 pesticides on land they farm. There must be at least one certified grower for each farm operation.

All agricultural assistants must also receive formal pesticide safety training, recognized by the Ministry of the Environment, before they can use Schedule 2 or 5 pesticides under the supervision of a certified grower. This applies to all assistants — including family members, farm employees and seasonal workers.

For more information about training for growers and agricultural assistants check the Ontario Pesticide Education Program Web site at *www.ridgetownc.uoguelph.ca/opep/* or call 1-800-652-8573.

### Requirements for Commercial Applicators and their Assistants

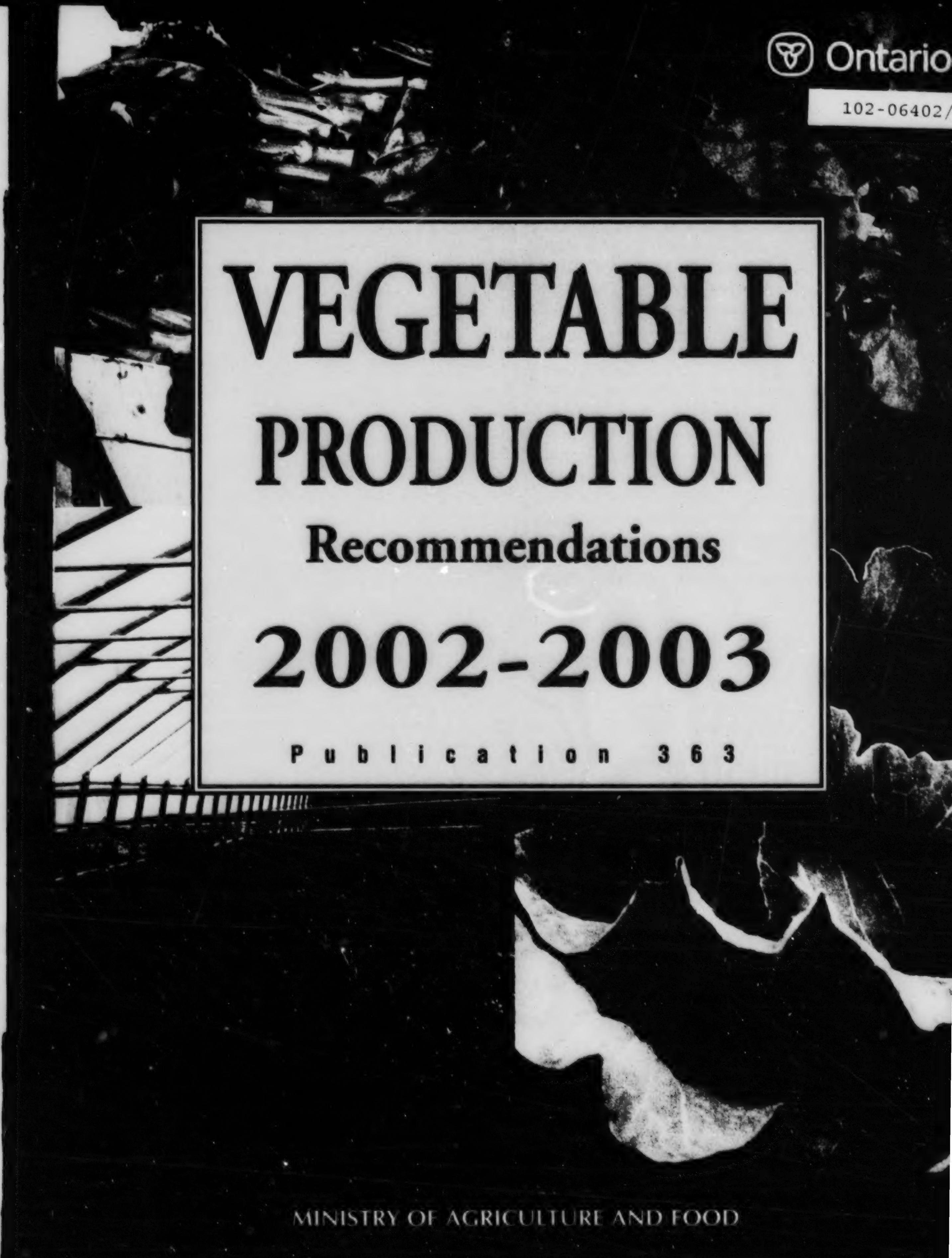
If you plan to apply pesticides as a business, you must be a licensed exterminator. **This includes farmers who custom apply pesticides for other farmers and charge a fee for this service.** You must complete a home study course and certification exam, and send proof of certification to the Ministry of Environment to obtain your license.

Unlicensed assistants must be Technicians before they may handle Schedule 2 (with restrictions), 3, 4 and 6 products under indirect supervision of a licensed exterminator. Technicians may not handle Schedule 1 and 5 products. For more information about exterminators and technicians check the Ontario Pesticide Training and Certification Web site at *www.ridgetownc.uoguelph.ca/optc* or call 1-888-620-9999.

*Cette publication est aussi disponible en français.*

Ontario

102-06402/



# VEGETABLE PRODUCTION

## Recommendations

## 2002-2003

Publication 363

MINISTRY OF AGRICULTURE AND FOOD

**Need technical or business information?**

Contact the Agricultural Information Contact Centre at:

1-877-424-1300 or ag.info@omafra.gov.on.ca

**Looking for vegetable production recommendations on the Internet?**

**www.gov.on.ca/OMAF/english/crops/index.html**

It's one-stop shopping for factsheets, articles and photos regarding the production and management of Ontario's vegetable crops.

---

**Acknowledgements**

The recommendations in this publication have been prepared in consultation with:

- Ontario Pest Management Research & Services Committee
- Ontario Horticultural Research & Services Committee
- Ontario Soil Management Research & Services Committee
- Ontario Weed Committee

and personnel of:

- Crop Technology, OMAF
- University of Guelph
- Ontario Ministry of Environment and Energy
- Agriculture and Agri-Food Canada

# Contents

## 1. Precautions With Pesticides

Pesticide Regulations ........ 1
  Certification and Training ........ 1
General Precautions ........ 2
  Personal Safety ........ 2
  Re-Entry Periods ........ 2
  Days to Harvest (Pre-Harvest), Pre-Grazing and Feeding Intervals ........ 2
Human Health ........ 3
  Toxicity ........ 3
  Exposure ........ 3
  Cholinesterase Blood Tests ........ 3
Protective Clothing and Equipment ........ 4
  Clothing ........ 4
  Equipment ........ 4
Application Procedures ........ 4
  Fumigants ........ 4
  Band Spraying ........ 5
  Seed Treatments ........ 5
  Aerial Application ........ 6
Pesticides and the Environment ........ 6
  Protect Water Sources ........ 6
  Spray Drift ........ 6
  Prevent Bee Poisoning ........ 6
Storing Pesticides ........ 7
Disposal of Pesticides and Empty Pesticide Containers ........ 7
  Rinsing ........ 7
  Disposal ........ 7
  Recycling ........ 7
  Paper and Cardboard Containers ........ 8
  Unwanted Pesticides ........ 8
  Surplus Spray Mix ........ 8
Pesticide Spills ........ 8

## 2. Soil Fertility

Assessing Nutrient Needs ........ 9
  Soil Testing ........ 9
  Plant Analysis ........ 10
  Micronutrient Tests ........ 11
Soil pH and Liming ........ 11
  Raising pH ........ 11
  Buffer pH ........ 11
  Limestone Quality ........ 11
  Lowering Soil pH ........ 12
Fertilizer Recommendations ........ 13
  Nitrogen ........ 13
  Phosphate and Potash ........ 13
  Magnesium ........ 13
  Calcium ........ 14
  Micronutrients ........ 16
Adjustments to Fertilizer Recommendations ........ 18
  Adjustments for Legumes Plowed Down ........ 18
  Manure ........ 18
  Biosolids ........ 20
Fertilizer Materials ........ 20
  Soluble Salts in Farm Soils ........ 20
  Toxicity of Fertilizer Materials ........ 21
  Guidelines for Safe Rates of Nutrients Applied at Seeding ........ 22
  Fertilizer Placement ........ 22
  Fertigation ........ 22

## 3. Soil Management

Soil Quality ........ 23
Subsidence of Peat and Muck Soils ........ 23
Tillage Systems ........ 23
  Conventional Tillage ........ 23
  Conservation Tillage ........ 24
  No-Till Systems ........ 24
Cover Crops ........ 25
  Grasses ........ 25
  Legumes ........ 26
  Non-Legume Broadleaves ........ 27
  Tillage Systems After Cover Crops ........ 28
Water Quality ........ 28
  Bacterial Contamination ........ 28
  Soil Erosion ........ 28
  Nitrate Contamination ........ 28

## 4. Vegetable Production Practices

Climate ........ 29
  Climate Zones and Planting Dates ........ 29
  Growing Degree Days and Crop Heat Units ........ 29
Seeding Practices ........ 31
  Seed ........ 31
  Plant Populations ........ 32
Plasticulture ........ 33
  Plastic Mulch ........ 33
  Row Covers ........ 33

  - Plastic Disposal 34
- Spraying Vegetable Crops 34
  - Water Volume and Pressure 34
  - Nozzle Selection 34
  - Air Temperature and Relative Humidity 34
  - Rainfall 34
  - Wind Speed & Drift 34
- Irrigation 35
  - Crops, Soils and Water Demand 35
  - Irrigation Systems 35
  - Irrigation Scheduling 36
  - Fertigation 36
- Food Safety 37
  - Preventing Biological Hazards 37
  - Good Agricultural Practices 37
- Storage 38
  - Storage Life for Fresh Vegetables 38
  - Ethylene 38
  - Commodity Compatibility 38
  - Storage Sanitation 38

## 5. Integrated Pest Management

- Thresholds 41
- Monitoring 41
  - Trapping 42
  - Scouting 42
- Pest Control Measures 42
  - Cultural and Mechanical 42
  - Chemical Controls 43
  - Beneficials 43
- Resistance Management 43
- General Insects and Diseases of Vegetable Crops 44
  - Damping-Off of Seedlings 44
  - Bacterial Diseases 44
  - Cutworms 44
  - Wireworm 44
  - Slugs 45
  - White Grubs 45
  - Seedcorn Maggot 45
  - Nematodes 45
  - Deer, Groundhogs and Rabbits 46

## 6. Crop Management Recommendations

- Asparagus 47
- Beans 51
- Beets, Table 55
- Carrots 58
- Celery 63
- Cole Crops: Broccoli, Brussels Sprouts, Cabbage, Cauliflower, Horseradish, Kale, Kohlrabi 68
- Cucurbits: Cucumber, Muskmelon, Watermelon, Pumpkin, Squash (also known as Vine Crops) 77
- Eggplant 83
- Garlic 85
- Herbs 87
- Lettuce, Endive & Parsley 88
- Onions, Leeks & Shallots 94
- Parsnips 100
- Peas 101
- Peppers 103
- Potatoes 107
- Radishes 122
- Rhubarb 125
- Rutabagas 126
- Specialty Vegetables 130
- Spinach & Swiss Chard 133
- Sugarbeets 136
- Sweet Corn 139
- Tomatoes 144
- Vegetable Transplants 151

## 7. Weed Management for Vegetable Crops

- Preplant Weed and Cover Crop Control 157
- Preplanting (PP) Treatments 157
- Selective Preemergence (PRE or PPI) Herbicides 158
  - Selective Postemergence (Post) Herbicides 158
- Principles of Integrated Weed Management 158
  - Cultural Methods of Weed Control 158
  - Critical Period of Weed Control 159
- Managing Weeds Resistant to Herbicides 160
  - Delaying Herbicide Resistance 160
  - Diagnosing Herbicide-Resistant Weeds 161
- Mechanical Methods of Weed Control 161
  - Preemergent or "Blind" Harrowing 161
  - Weeder Harrow 161
  - Rotary Hoe 161
  - Inter-Row Cultivation 161
  - Mowing 162
- Use of Chemicals to Control Weeds 162
  - Time of Herbicide Treatment in Crop Areas 162
  - Chemical Weed Control in Non-Crop Areas 162
  - Conservation Tillage 163
  - Applying Herbicides 164
- Notes on Herbicides for Vegetables 164
- Notes on Adjuvants for Vegetables 185
- Special Methods of Weed Control 194
  - Preplant-Site Preparation Prior to Any Crop 194
  - Stale Seedbed and Inter-Row Weeding 195
  - Post-Harvest (Broadleaf Herbicides) 196
  - Post-Harvest (Grass and Broadleaf Herbicides) 196

Spot Treatment With Handheld Equipment for Selective Weed Control ... 197
Wick Wiper and Roller Application ... 198
Seedbeds and Potting Soil: Soil-Applied Fumigants ... 198
Vegetable Weed Control Recommendations ... 201
Asparagus ... 201
Beans (Lima and Snap) ... 207
Beets (Table) ... 212
Cabbages, Cauliflower, Broccoli, Brussels Sprouts ... 213
Carrots ... 215
Celery ... 219
Cucumbers ... 219
Garlic ... 220
Ginseng ... 221
Herbs ... 222
Leeks ... 223
Lettuce ... 223
Muskmelons, Watermelons, Squash and Pumpkins ... 224
Onions ... 225
Parsnips ... 227
Peas ... 228
Peppers ... 231
Potatoes ... 232
Rutabagas ... 237
Specialty Vegetables ... 238
Spinach ... 240
Sugarbeets (Processing) ... 241
Sweet Corn ... 246
Sweet Potatoes ... 259
Tomatoes (Transplanted) ... 259
Water Weeds (Aquatic Plants) ... 266

## 8. Appendices

Appendix A. Pesticides Used on Vegetable Crops in Ontario ... 271
Appendix B. Pest Control Product Companies ... 281
Appendix C. Ontario Ministry of the Environment and Energy Pesticide Control Offices ... 282
Appendix D. Accredited Soil-Testing Laboratories in Ontario ... 283
Appendix E. Crop Insurance ... 284
Appendix F. Other Contacts ... 285
Appendix G. Diagnostic Service ... 286
Appendix H. Ontario Ministry of Agriculture and Food Staff ... 288
Appendix I. The Metric System ... 291

# Tables

## 1. Precautions With Pesticides

Table 1–1. Pesticide Schedules in Ontario ... 1
Table 1–2. Safety Supply Companies in Ontario Providing Protective Clothing & Equipment ... 5
Table 1–3. Relative Toxicity of Insecticides to Honeybees ... 7
Table 1–4. Pesticide Act Storage Requirements ... 7

## 2. Soil Fertility

Table 2–1. OMAF-Accredited Soil Tests ... 9
Table 2–2. Soil pH at Which Lime Is Recommended for Ontario Field-Grown Crops ... 11
Table 2–3. Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH ... 12
Table 2–4. Example Calculation of the Fineness Rating of Limestone ... 12
Table 2–5. Phosphorus Requirements: Vegetables on Mineral Soils ... 14
Table 2–6. Potassium Requirements: Vegetables on Mineral Soils ... 15
Table 2–7. Phosphorus and Potassium Requirements: Vegetables on Muck Soils ... 15
Table 2–8. Application Rates for Magnesium, Calcium and Micronutrients ... 16
Table 2–9. Response of Crops to Micronutrient Fertilizers ... 17
Table 2–10. Manganese Availability Index ... 17
Table 2–11. Zinc Soil Index Interpretation ... 18
Table 2–12. Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down ... 18
Table 2–13. Average Amounts of Available Nutrients for Different Types of Manure ... 19
Table 2–14. Fertilizer Materials: Primary Nutrients ... 21
Table 2–15. Fertilizer Materials: Secondary and Micronutrients ... 21
Table 2–16. Soil Conductivity Reading Interpretation ... 22

## 3. Soil Management

Table 3–1. Maintaining or Improving Soil Quality ................ 24
Table 3–2. Characteristics of Cover Crops Grown in Ontario ................ 25

## 4. Vegetable Production Practices

Table 4–1. Average Frost-Free Period in Climatic Zones of Ontario ................ 30
Table 4–2. First Field Seeding or Planting Dates for Commercial Production ................ 31
Table 4–3. Vegetable Seed Life Expectancy ................ 31
Table 4–4. Number of Plants per Hectare at Various Planting Distances ................ 32
Table 4–5. Row Length per Acre or per Hectare at Various Row Spacings ................ 32
Table 4–6. Approximate Planting Depth and Seeds per Gram ................ 32
Table 4–7. Plastic Mulch Types ................ 33
Table 4–8. Classification of Vegetable Crops by Rooting Depth ................ 35
Table 4–9. Critical Periods for Irrigation of Several Vegetable Crops ................ 35
Table 4–10. Nitrogen and Potash Injection Schedules ................ 37
Table 4–11. Storage Life for Fresh Vegetables in Commercial Storage ................ 39
Table 4–12. Proven Disinfectants ................ 40

## 5. Integrated Pest Management

Table 5–1. Monitoring Equipment Suppliers ................ 42

## 6. Crop Management Recommendations

Table 6–1. Rust Control Recommendations for Asparagus ................ 48
Table 6–2. Insect Control Recommendations for Asparagus ................ 49
Table 6–3. Bean Cultivars With Disease-Resistant Traits ................ 51
Table 6–4. Spacing and Seeding Rates for Snap Beans ................ 51
Table 6–5. Bean Seed Treatments ................ 52
Table 6–6. Disease Control Recommendations for Beans ................ 53
Table 6–7. Insect Control Recommendations for Beans ................ 54
Table 6–8. Table Beet Cultivars With Disease-Resistant Traits ................ 55
Table 6–9. Table Beet Seed Treatments ................ 56
Table 6–10. Disease and Insect Control Recommendations for Table Beets ................ 57
Table 6–11. Suggested Carrot Cultivars ................ 58
Table 6–12. Carrot Seed Treatments ................ 59
Table 6–13. Carrot Disease Control Recommendations ................ 60
Table 6–14. Carrot Insect Control Recommendations ................ 61
Table 6–15. Celery Nitrogen Recommendations ................ 63
Table 6–16. Suggested Celery Cultivars ................ 63
Table 6–17. Celery Blight Control Recommendations ................ 64
Table 6–18. Celery Insect Control Recommendations ................ 66
Table 6–19. Seeding and Spacing of Cole Crop Vegetables ................ 68
Table 6–20. Cole Crop Nitrogen Recommendations ................ 68
Table 6–21. Suggested Cole Crop Cultivars ................ 69
Table 6–22. Cole Crop Seed Treatments ................ 70
Table 6–23. Cole Crop Disease Control Recommendations ................ 71
Table 6–24. Root Maggot Control Recommendations for Cole Crops ................ 72
Table 6–25. Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations for Cole Crops ................ 73
Table 6–26. Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops ................ 75
Table 6–27. Aphid Control Recommendations for Cole Crops ................ 76
Table 6–28. Suggested Cucurbit Crop Cultivars ................ 77
Table 6–29. Common Spacings for Cucurbit Crops ................ 78
Table 6–30. Cucurbit Disease Control Recommendations ................ 80
Table 6–31. Cucurbit Insect Control Recommendations ................ 81
Table 6–32. Pumpkin and Squash Storage Expectancy ................ 82
Table 6–33. Suggested Eggplant Cultivars ................ 83
Table 6–34. Eggplant Insect Control Recommendations ................ 84
Table 6–35. Garlic Disease and Insect Control Recommendations ................ 86
Table 6–36. Herb Type, Propagation, Parts Harvested/Sold ................ 87
Table 6–37. Suggested Lettuce Cultivars ................ 88
Table 6–38. Lettuce Seed Treatments ................ 89
Table 6–39. Lettuce and Parsley Disease Control Recommendations ................ 90
Table 6–40. Lettuce, Endive and Parsley Insect Control Recommendations ................ 91
Table 6–41. Aphid Control Recommendations for Lettuce and Parsley ................ 92
Table 6–42. Suggested Allium Cultivars ................ 95
Table 6–43. Onion Seed Treatments ................ 96
Table 6–44. Onion Disease Control Recommendations ................ 97
Table 6–45. Onion and Leek Insect Control Recommendations ................ 98
Table 6–46. Suggested Parsnip Cultivars ................ 100
Table 6–47. Parsnip Disease and Insect Control Recommendations ................ 100
Table 6–48. Suggested Pea Cultivars ................ 101
Table 6–49. Pea Seed Treatments ................ 101
Table 6–50. Pea Insect Control Recommendations ................ 102
Table 6–51. Suggested Pepper Cultivars ................ 103

Table 6–52. Pepper Disease and Insect Control Recommendations ........ 105
Table 6–53. Main Potato Cultivars Grown in Ontario and Their Uses ........ 107
Table 6–54. Canadian Seed Classes ........ 110
Table 6–55. Potato Seed Piece Treatment Recommendations ........ 111
Table 6–56. Nitrogen Recommendations for Potatoes ........ 112
Table 6–57. Interpretation of Plant Analysis for Potatoes ........ 113
Table 6–58. Potato Disease Control Recommendations ........ 115
Table 6–59. Potato Insect Control Recommendations ........ 118
Table 6–60. Colorado Potato Beetle Control Recommendations ........ 119
Table 6–61. Suggested Radish Cultivars ........ 122
Table 6–62. Radish Insect Control Recommendations ........ 124
Table 6–63. Suggested Rhubarb Cultivars ........ 125
Table 6–64. Rutabaga Seed Treatments ........ 126
Table 6–65. Rutabaga Disease Control Recommendations ........ 127
Table 6–66. Rutabaga Insect Control Recommendations ........ 128
Table 6–67. Specialty Vegetables ........ 131
Table 6–68. Specialty Vegetables Disease and Insect Control Recommendations ........ 132
Table 6–69. Suggested Spinach Cultivars ........ 133
Table 6–70. Spinach and Swiss Chard Insect Control Recommendations ........ 134
Table 6–71. Spinach Seed Treatments ........ 135
Table 6–72. Sugarbeet Row Spacing ........ 136
Table 6–73. Sugarbeet Seed Treatments ........ 137
Table 6–74. Disease and Insect Control Recommendations for Sugarbeets ........ 138
Table 6–75. Sweet Corn Cultivars With Disease-Resistance Traits ........ 140
Table 6–76. Sweet Corn Seed Treatments ........ 141
Table 6–77. Sweet Corn Insect and Disease Control Recommendations ........ 142
Table 6–78. Corn Earworm Spray Intervals ........ 143
Table 6–79. Suggested Tomato Cultivars ........ 144
Table 6–80. Plant Spacing for Tomatoes ........ 144
Table 6–81. Nitrogen Recommendations for Processing Tomatoes ........ 145
Table 6–82. Starter Solution Recommendations for Tomatoes ........ 145
Table 6–83. Tomato Disease Control Recommendations ........ 146
Table 6–84. Tomato Insect Control Recommendations ........ 149
Table 6–85. Relative Ease of Transplanting Vegetables ........ 151
Table 6–86. Suitable Tray Sizes for Various Vegetable Species ........ 151
Table 6–87. Vegetable Transplant Requirements ........ 153
Table 6–88. Acceptable Ranges of Water Quality and Correction Methods ........ 154
Table 6–89. Analysis for Various Soluble Fertilizers ........ 155
Table 6–90. Fertility Guidelines for Vegetable Transplants ........ 155
Table 6–91. Disease Control Recommendations for Vegetable Transplants in the Greenhouse ........ 156

### 7. Weed Management for Vegetable Crops

Table 7–1. Critical Weed-Free Period for Horticultural Crops ........ 159
Table 7–2. Adjuvants Used in Ontario ........ 184
Table 7–3. Herbicide Groupings for Ontario ........ 190
Table 7–4. Interval Before Rainfall (Postemergence) ........ 191
Table 7–5. Herbicide Crop Rotation and Soil pH Restrictions – Horticultural Crops ........ 192
Table 7–6. Herbicide Crop Rotation and Soil pH Restrictions – Field Crops ........ 193
Table 7–7. Non-Selective Herbicides Available for Preplant Site Preparation ........ 199
Table 7–8. Preplant Herbicide Weed Control Ratings ........ 200
Table 7–9. Beans (Lima and Snap) Herbicide Weed Control Ratings ........ 211
Table 7–10. Comparative Growth Stages of Corn ........ 256
Table 7–11. Sweet Corn Herbicide Weed Control Ratings ........ 257
Table 7–12. Vegetable Herbicide Weed Control Ratings ........ 264

## Figures

### 4. Vegetable Production Practices

Figure 4–1. Climate Zone Map of Ontario ........ 30

### 7. Weed Management for Vegetable Crops

Figure 7–1. Stages of Corn Leaf Development (Leaf-Over Method) ........ 256

# 1. Precautions With Pesticides

## Pesticide Regulations

**You must report all major spills, fires or thefts involving pesticides to the Ontario Ministry of Environment and Energy at 1-800-268-6060. (*Regulation 914, s.29*)**

The Ontario Ministry of the Environment and Energy reviews each pesticide product offered for sale in Ontario and classifies it into one of six groupings called Schedules. See Table 1–1, *Pesticide Schedules in Ontario*, below, for a description of these schedules.

## Certification and Training

You must be a certified grower or a licensed applicator (exterminator) to buy and use Schedule 1, 2 and 5 pesticides.

### *Certification for Farmers*

Regulation 914 of the *Pesticides Act* makes it mandatory for farmers to be certified through the Grower Pesticide Safety Course to buy and use Schedules 1, 2 or 5 pesticides on land they farm.

- There must be at least one certified grower for each farm operation.
- Under the *Pesticides Act*, you are a grower (farmer) if you currently use farm land for agricultural or forestry production, and if that farmland is classified as farmlands property under Section 7 of the *Ontario Assessment Act*.

### *Training for Agricultural Assistants*

As of January 2000, all assistants must have formal pesticide safety training, recognized by the Ministry of the Environment and Energy, before they can handle or use Schedule 2 or 5 pesticides under the supervision of a certified grower.

This applies to all assistants, including family members, farm employees and seasonal workers. Trained assistants must be 16 years of age or older. They do not have to write an exam. There are two training options for assistants:

- attend a Grower Pesticide Safety Course and not write the certification examination, or

**Table 1–1.**
**Pesticide Schedules in Ontario**

| Schedule | Who Can Use It | Pesticide Characteristics[1] |
|---|---|---|
| 1 | • licensed applicator<br>• certified grower<br>• only with approved permit | • very toxic and/or<br>• very persistent and/or<br>• highly mobile |
| 2 | • licensed applicator<br>• certified grower<br>• trainee or technician under supervision (some restrictions apply)<br>• assistant agriculturist under supervision | • toxic, and/or<br>• persistent, and/or<br>• moderately mobile |
| 3 | Any person | • moderately toxic, and/or<br>• moderately persistent, and/or<br>• slightly mobile |
| 4 | Any person | • low toxicity<br>• non-persistent<br>• non-mobile<br>• containers < 1kg < 1L |
| 5 | • licensed applicator<br>• certified grower<br>• assistant agriculturist under supervision | • very toxic and/or<br>• very persistent and/or<br>• highly mobile<br>• less toxic or less persistent alternative not available |
| 6 | Any person | • low toxicity<br>• non-persistent<br>• non-mobile<br>• containers > 1 kg > 1L |

[1] Biological persistence and mobility in the environment, as expected under normal use conditions for Ontario.

- attend an on-farm training session presented by a qualified trained assistant instructor.

### Commercial Applicators and Exterminators

You must be a licensed exterminator if you plan to apply pesticides as a business. This includes farmers who custom-apply pesticides for other farmers and charge a fee for this service. Licensed exterminators who are self-employed must hold an operator licence as well as the appropriate exterminator licence. Exterminator licences are valid for 5 years.

To become a licensed exterminator, you must:

- complete a home study course and certification exam through Ridgetown College, University of Guelph, and
- send proof of certification (letter of successful completion of the exam(s)) and a fee to the Ministry of the Environment and Energy to obtain your exterminator licence.

### Technicians

Technicians can mix, load or apply all Schedule 3, 4 and 6 pesticides and most Schedule 2 pesticides (some restrictions apply), under the indirect supervision of a licensed exterminator. Technicians cannot mix, load or apply Schedule 1 or 5 pesticides. Technician cards are valid for 2 years.

To become a technician, you must:

- complete an MOEE-approved academic course and exam, and
- complete practical training with a licensed exterminator.

**For more information on certification and training, contact the Ontario Pesticide Education Program.**

**Phone: 1-800-652-8573**

**E-mail: opep@ridgetownc.uoguelph.ca**

**Web site: www.ridgetownc.uoguelph.ca/opep**

## General Precautions

**Always read the label first!**

- **Before you buy a pesticide**
- **Before you begin to use a pesticide**
- **Before you store a pesticide or dispose of it**

Learn about the health hazards and toxic properties of the pesticide you are using. Consult the product label, Material Safety Data Sheets (MSDS), or manufacturer for this information. Check the company Web sites for MSDS information (see Appendix B, *Pest Control Product Companies*, on page 281).

Check the label for special warnings about eye hazards and skin hazards. The front panel of the pesticide label may also contain warnings that tell you the product is corrosive to eyes, or is a skin or eye irritant.

### Personal Safety

- Make sure someone knows where you are working, what pesticides you are handling and how long you expect the job to take.
- Post emergency numbers, including those for the Poison Information Centre and the Spills Action Centre near all of your telephones.
- Keep a list of the names and the Pest Control Products (PCP) Act registration numbers of all the pesticides you handle. It's a good idea to keep a file of the pesticide label booklets for all the products you use. Make sure that your co-workers and family members know where this list or file is in case of an accident.
- Have plenty of clean water, soap and paper towels – and an extra set of gloves and coveralls – nearby at all times in case pesticide contaminates your clothing or skin.
- Wear the correct protective clothing and equipment, and be sure that all items are clean and in good repair before you put them on.
- Never smoke, chew tobacco, eat or drink when you handle pesticides. Never carry tobacco or food in your clothes. Never leave tobacco, food or beverages in areas where you handle or store pesticides.
- Change your clothes and wash your hands and face before you eat, drink or smoke.
- Wash your hands before you use the toilet, as well as after. The skin in your groin area absorbs pesticides very easily.
- Pregnant women should not handle or use pesticides.

### Re-Entry Periods

Re-entry period is the minimum amount of time that must pass between the time a pesticide was applied and the time that workers can go into the crop without wearing personal protective equipment. Early entry into a field without protective equipment may result in poisoning resulting from handling treated plants or from inhaling pesticide vapours. **Re-entry periods are listed with the pest control recommendations for each individual commodity section in Chapter 6,** ***Crop Management Recommendations*****, on page 47.**

### Days to Harvest (Pre-Harvest), Pre-Grazing and Feeding Intervals

These intervals state the minimum amount of time that must pass between the last pesticide application and the harvesting of the crop, or the grazing or cutting of the crop for livestock feed.

If you harvest a crop before the pre-harvest interval has passed, there may be pesticide residues in excess of the maximum residue limits (MRL) set by Health Canada. When crops with persistent residues are fed to livestock, the pesticides may poison the animal or may contaminate the milk or meat. Refer to the commodity sections in Chapter 6 for product-specific days to harvest intervals and feeding restrictions.

**To avoid exceeding the maximum residue limits, always follow the instructions on the label.**

## Human Health

Each time you handle a pesticide, you are at some risk. The amount of risk depends on two things – the toxicity of that pesticide and your exposure to it.

**Risk = Toxicity x Exposure**

### Toxicity

Toxicity is a measure of how harmful or poisonous the pesticide is. There are two types of toxicity – acute and chronic.

#### *Acute Toxicity*

Acute toxicity is the toxic response that results from a single exposure to the pesticide. The symbols and words on the front panel of a pesticide label give you information about the acute toxicity.

Examples of products listed in this publication with a high acute toxicity include:

| Common name | Trade name |
|---|---|
| azinphos-methyl | Guthion, APM, Sniper |
| carbofuran | Furadan |
| disulfoton | Di-Syston |
| endosulfan | Thiodan, Thionex |
| methamidaphos | Monitor |
| methomyl | Lannate |
| oxamyl | Vydate |
| parathion | Parathion |
| phorate | Thimet |
| terbufos | Counter |

**Lethal Dose 50% (LD$_{50}$)** is a measure of acute toxicity. It is the dose (in mg of product per kg of body weight) that will kill 50% of the test animals within a stated period of time (24 hours to 7 days).

#### *Chronic Toxicity*

Chronic toxicity results from repeated exposure to small doses of a pesticide over a longer period of time. These toxic effects may not appear for months or years after exposure to the pesticide. The symbols on the label do NOT give information about the chronic toxicity of the product. Use protective clothing and equipment to help reduce exposure and the risk of chronic effects.

### Exposure

You can be exposed to the pesticide in three ways:

1. **Dermal exposure** occurs through your skin or eyes. The amount and rate of exposure depends on several factors. Pesticides are absorbed more easily by moist skin. Rashes, cuts and abrasions also increase dermal pesticide exposure.
2. **Respiratory exposure (inhalation)** occurs when you inhale small spray particles, dust, gases or vapours.
3. **Oral exposure** occurs when a pesticide enters your mouth or you swallow a pesticide.

If symptoms of illness occur during or shortly after handling a pesticide, go to a hospital. Take the pesticide label, MSDS or pesticide container with you. Do not transport the container in the passenger compartment of the vehicle. **Refer to the Emergency Procedures for Pesticide Poisoning on the inside back cover.**

### Cholinesterase Blood Tests

*Organophosphate* and *carbamate* pesticides can affect your nervous system by affecting the levels of an enzyme called acetyl cholinesterase in your blood and serum. Your body uses this enzyme to transmit messages through your nervous system. If your cholinesterase levels fall, you can experience symptoms including trembling, twitching, blurred vision, difficulty breathing and heart difficulties.

If you use any of the organophosphate or carbamate pesticides on a regular basis, have regular cholinesterase blood tests. Your family doctor can arrange these tests. They are covered by OHIP.

Have your first test during the off-season *before* you begin to handle these pesticides. It will identify the baseline (normal) cholinesterase level for your body. During the spray season, if you are spraying organophosphorus or carbamate insecticides, have a cholinesterase blood test regularly.

If your cholinesterase level drops to below one-half of your baseline level, then you are showing signs of pesticide poisoning and you must remove yourself from exposure to these pesticides until your cholinesterase level returns to normal.

## Protective Clothing and Equipment

The protective clothing and equipment you need to wear depends on:

- **The pesticide you are using** Read the precautions section of the label for clothing and equipment requirements.
- **The job you are doing** For example, you need more protection when you handle concentrated pesticide or when you mix and load your sprayer.
- **The type of application** Applications in enclosed spaces or air blast sprayer applications made with open tractors require more equipment.

Each person who is working with pesticides needs his or her own set of protective clothing and equipment. Consult the technical expert at your safety supply company to make sure that you purchase the appropriate equipment and that it fits the user. For a list of protective clothing and respirator supplies, see Table 1–2, *Safety Supply Companies in Ontario Providing Protective Clothing & Equipment*, on page 5.

### Clothing

For ALL pesticides, always wear:

- Water repellent hat. Do not wear hats made from cloth.
- Long pants and a shirt with long sleeves, or a coverall. Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. Water-resistant coveralls are preferred because cotton, denim and cotton/polyester pants cling to the skin if they get wet, increasing the risk of dermal exposure.
- Chemical-resistant gloves (unlined). Use neoprene or nitrile gloves, unless the label states otherwise. Do not wear rubber gloves, as many pesticides can break down the rubber material. Wear your gloves under your sleeves with the top cuffed.
- Chemical-resistant boots (unlined).

Cotton, denim and cotton-polyester fabrics can absorb pesticides and transfer pesticides to your skin. If you spill pesticide on your clothing, remove the clothing immediately.

#### *Care of Protective Clothing*

After you complete the spray operation, clean all protective clothing and equipment. Always remove protective clothing and equipment outdoors. If you were using a granular pesticide, shake the clothing outdoors in a safe place, emptying pockets and cuffs.

Wash coveralls and other spray clothing separately from other clothes. Throw out clothing that has been contaminated by spills of highly toxic or concentrated pesticide. Place clothing in a plastic bag and take it to a landfill site.

### Equipment

**When you work with fumigants, gasses or vapours or when you apply any pesticide in an enclosed area, ALWAYS wear a respirator.**

#### *Respirator*

A respirator is a unit that covers your mouth and nose to prevent spray droplets, small particles and vapours from getting into your lungs. A dust mask is not a substitute for a pesticide respirator. Make sure you use cartridges and pre-filters that protect you against organic vapours when you buy a respirator or replacement cartridges. For more information about respirators, refer to the *Grower Pesticide Safety Course Manual*, Ridgetown College, University of Guelph.

#### *Canister Gas Masks*

Canister gas masks are effective for protection against certain gasses, vapours and particulate matter. They are generally suitable for ventilated areas. They should never be used in confined spaces where oxygen deficiency and high gas concentrations may occur.

#### *Self-Contained Breathing Apparatus (SCBA)*

Use a self-contained breathing apparatus when you apply any pesticide in an enclosed area or when using fumigants, gases, vapours or smokes.

#### *Organic Vapour Tractor Cab Cartridges*

If you use a tractor with a cab when you spray, use tractor cab cartridges, which work the same way as an air-purifying respirator. To provide continued protection, replace and maintain these cartridges and pre-filters regularly.

## Application Procedures

### Fumigants

Read and follow all instructions on the product label regarding protective clothing and equipment, aeration of treated areas and re-entry periods. Lock the building and post warning signs. As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation. (This is a requirement for all fumigant gas use.)

## Table 1–2.
## Safety Supply Companies in Ontario Providing Protective Clothing & Equipment

| | | |
|---|---|---|
| **3-M Canada Inc.** | Occupational Health and Environmental Safety<br>Box 5757<br>London, ON N6A 4T1 | (519) 452-6165<br>1-800-364-3577<br>Fax: (519) 452-4660 |
| **Acklands Grainger** | 90 W. Beaver Creek Rd.<br>Richmond Hill, ON L4B 1E7 | (905) 731-5516<br>1-800-368-8989<br>Fax: (905) 731-2798 |
| **Aearo Canada** | 7115 Tomken Rd.<br>Mississauga, ON L5S 1X7 | (905) 795-0700<br>1-800-387-4304<br>Fax: (905) 564-5250 |
| **Dutch Industries<br>"Protect-Air Cab Filter"** | Huron Tractor, Box 1300<br>Exeter, ON N0M 1S3 | (519) 235-1115<br>Fax: (519) 255-1939 |
| **HAMISCO** | 3392 Wonderland Rd.<br>London , ON N6L 1A8 | (519) 652-9800<br>1-800-668-9800<br>Fax:(519) 652-9661 |
| **Kappler Canada** | Box 1687<br>20 Ryan Place<br>Brantford, ON N3T 5V7 | (519) 752-4369<br>1-800-387-9326<br>Fax: (519)752-2161 |
| **Levitt-Safety (Eastern) Limited** | 2872 Bristol Circle<br>Oakville,ON L6H 5T5 | (905) 829-3299<br>1-800-668-6153<br>Fax: (905) 829-2919 |
| **MSA Canada Inc.** | 148 Norfinch Dr.<br>North York, ON M3N 1X8 | (416) 667-9400<br>1-800-267-0672<br>Fax: (416) 663-5908 |
| **Mitt & Robe Co.** | 751 Norfolk St. N.<br>Simcoe, ON N3Y 3R6 | (519) 428-4050<br>1-877-893-6565<br>Fax: (519) 428-5142 |
| **Plant Products Co. Ltd.** | 314 Orenda Rd.<br>Brampton, ON L6T 1G1 | (905) 793-7000<br>1-800-387-2449<br>Fax: (905) 793-9632 |
| **Safety Express** | 4060B Sladeview Cres., Unit 2<br>Mississauga, ON L5L 5Y5 | (905) 608-0111<br>1-800-465-3898<br>Fax: (905) 608-0091 |
| **The Saint George Company<br>(Suppliers of Kasco Helmets)** | P.O. Box 430<br>20 Consolidated Dr.<br>Paris, ON N3L 3T5 | (519) 442-2046<br>1-800-461-4299<br>Fax: (519) 442-7191 |

If you use a fumigant gas such as methyl bromide plus chloropicrin or aluminum phosphide to fumigate a structure, you must hold the appropriate licence **and** obtain a permit issued under Ontario's *Pesticides Act*. To apply for a permit, contact the regional pesticides officer with the Ontario Ministry of the Environment and Energy.

When you handle methyl bromide, *do not* wear gloves. Wear a self-contained positive-pressure breathing apparatus. When you handle aluminum phosphide, use cotton gloves and wear a full-face mask respirator with an acid gas canister, or a self-contained positive-pressure breathing apparatus.

For more information, refer to *Structural Fumigation Procedures (September 1998 edition)* from the Ontario Ministry of the Environment and Energy.

## Band Spraying

When banding pesticides, apply the recommended rate over the strip of row you wish to treat. Banding does not result in a more concentrated spray mixture. It does allow you to cover more area with the same amount used in a broadcast application. Check the product label under Directions for Use. Some labels give specific nozzle recommendations and formulas to determine band application rates.

To know how much to mix, you will first need to calculate the size of the entire treated area. To calculate the total area of all the treated bands:

$$\underset{\text{(ha or acres)}}{\textbf{Total Area of Bands}} = \underset{\text{(ha or acres)}}{\textbf{Total Area of Planted Field}} \times \frac{\textbf{Band Width}\ \text{(cm or in)}}{\textbf{Row Spacing}\ \text{(cm or in)}}$$

## Seed Treatments

Remember that treated seed products are also pesticides. They are poisonous to people and animals.

Wear protective clothing and equipment when you are treating seed or handling treated seed. Protect your skin. Wear a long-sleeved shirt, long pants or coveralls and wear neoprene or nitrile gloves. Protect your eyes with goggles and/or a face shield. Wear a respirator to protect your lungs from dusts and vapours.

Wash thoroughly after finishing the treatment or handling the treated seed. Never feed treated seed to animals. Keep treated seed out of the reach of children.

Destroy all the bags that have held treated seed as recommended in the section *Disposal of Pesticides and Empty Pesticide Containers*, on page 7.

### Aerial Application

Any person who applies pesticide from an aircraft in Ontario **must** hold an aerial exterminator licence. In addition, he or she needs permits from the Ministry of the Environment and Energy to apply Schedule 1 and 5 pesticides and schedule 2 hormone-type herbicides.

Pesticides approved for aerial application are labelled as such. Aerial application is crop specific. Label rates, conditions and precautions are specific to each product and crop use. Do not apply any given product unless the label states an aerial application rate for the specific crop. Do not allow the pilot to mix chemicals to be loaded into the aircraft.

Take extra precautions when using insecticides applied by air that are toxic to honeybees. See the section *Prevent Bee Poisoning*, right.

······················································

## Pesticides and the Environment

### Protect Water Sources

Use an anti-backflow device to prevent back-siphoning when drawing water from wells, ponds, streams or other sources.

Mix pesticide and load the sprayer **at least 50 m away** from any water supply, including wells, ponds or streams.

Use buffer zones (untreated areas) when you apply pesticides to avoid contaminating surface water, wells, ponds and/or streams. Check the product label for specific buffer zone distances.

### Spray Drift

Spray only when winds are light to moderate. If you notice drift is occurring because of the wind, **stop spraying** until the wind subsides. Do not apply pesticides if the wind is blowing towards susceptible crops or environmentally sensitive areas such as watercourses.

### Ten Ways to Reduce Drift

1. Read product label thoroughly.
2. Don't spray under windy conditions.
3. Use buffer strips.
4. Use higher water rates: bigger nozzles = bigger drops.
5. Use drift-reducing types of nozzles.
6. Understand weather influences on droplet management.
7. Use hood, shroud, screen or air-assist boom spray plume protection.
8. Follow label instructions for adjuvents.
9. Use wick-weeders, which do not produce droplets.
10. Minimize nozzle-to-target distance.

For more information about spray drift, consult the OMAF Factsheet, *Reducing Pesticide Drift and Crop Damage*, Order No. 00-103, the OMAF/Agriculture and Agri-Food Canada booklet *Best Management Practices: Pesticide Storage, Handling and Application* and the Ontario Pesticide Education Program (Ridgetown College) videos *How to Manage Spray Drift* and *Spray Drift Reduction Through Air Induction*.

### Prevent Bee Poisoning

It is important to protect bees when you spray. Honeybees, as well as other bees and insects, are valuable crop pollinators. Many crops also offer bees important sources of pollen for honey production.

If you choose to use insecticides for insect control, take these steps to prevent harming bees when you spray:

- Before you apply a pesticide, advise local beekeepers so that they can move colonies out of the danger area. Contact the Provincial Apiarist at 1-888-466-2372 for a list of the beekeepers in your area.
- Do not spray any flowering crop on which bees are foraging. If you must apply insecticides, spray after 7 PM when bees are not foraging.
- Do not apply insecticide on windy days, to prevent drift toward any nearby hives.
- When there is a choice, choose the product formulation that is less hazardous to bees. Dusts are more toxic than sprays. EC formulations are less toxic than WP formulations.
- Under the *Bees Act*, it is an offence to spray in orchards while there is bloom on the trees.

### Table 1–3.
### Relative Toxicity of Insecticides to Honeybees

| Trade Name | Common Name |
|---|---|
| **Group 1. Very toxic. Do not apply to flowering crops or weeds** | |
| Diazinon, DZN | diazinon |
| Cygon, Lagon | dimethoate |
| Furadan | carbofuron |
| Guthion, Sniper, AMP | azinphos-methyl |
| Imidan | phosmet |
| Lannate | methomyl |
| Lorsban, Pyrifos, Pyrinex | chlorpyrifos |
| Malathion | malathion |
| Monitor | methamidophos |
| Pounce | permethrin |
| Parathion | parathion |
| Ripcord, Cymbush | cypermethrin |
| Sevin | carbaryl |
| **Group 2. Apply only during late evenings or early morning.**[1] | |
| Decis | deltamethrin |
| Di-syston | disulfoton |
| Endosulfan,Thiodan | endosulfan |
| Pirimor | pirimicarb |

[1] Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Most organophosphate and carbamate insecticides are highly toxic to bees. Examples of insecticides used in crop production that are toxic to bees are listed in Table 1–3, *Relative Toxicity of Insecticides to Honeybees*, above.

**Read each pesticide label for specific precautions regarding bees.**

## Storing Pesticides

Ontario's *Pesticides Act* and Regulation 914 give storage requirements for storage facilities. The storage requirements that you must follow depend on which Schedules of pesticides that you store. See Table 1–4, *Pesticide Act Storage Requirements*, right.

See also the OMAF Factsheet, *Pesticide Handling Facilities*, Order No. 94-037.

### Table 1–4.
### Pesticide Act Storage Requirements

| | Schedule 3, 4 & 6 | Schedule 2 | Schedule 1 & 5 |
|---|---|---|---|
| No contact with food or drink | ◆ | ◆ | ◆ |
| Do not impair health/safety | ◆ | ◆ | ◆ |
| Clean & orderly manner | ◆ | ◆ | ◆ |
| Warning signs posted on storage buildings | ◆ | ◆ | ◆ |
| Warning signs posted on unattended vehicles | ◆ | ◆ | ◆ |
| Emergency telephone numbers posted | ◆ | ◆ | ◆ |
| Ventilated to outside | | ◆ | ◆ |
| Limited access (locked) | | ◆ | ◆ |
| No floor drain | | ◆ | ◆ |
| Safety equipment available | | ◆ | ◆ |
| Area used exclusively for pesticides | | | ◆ |

## Disposal of Pesticides and Empty Pesticide Containers

### Rinsing

Unrinsed pesticide containers are not really "empty." They may still hold about 1% of the original amount of pesticide. Although this figure sounds low, it is still a hazard to humans, animals and the environment. To reduce the hazard, rinse each container three times as the spray tank is filling. Use either the manual triple rinse technique or a specially designed device for rinsing containers.

Once containers are properly rinsed, they should be punctured to make it impossible to use them again and to make sure the rinse water is out of the container.

### Disposal

Never re-use empty pesticide containers. They may be handy, but there is still some risk even if the containers are triple rinsed. Never give empty, rinsed containers to anyone, especially not children. Dispose of them promptly.

It is often more convenient to store empty, rinsed containers until you have collected enough to make a trip to the recycling pesticide container depot or the waste disposal site. If you store containers, keep them in a dry, safe place, such as the storage area, until you can dispose of them properly.

### Recycling

The Ontario Pesticide Container Recycling Program is available to growers and commercial applicators. Through this program, clean, triple rinsed, plastic/metal pesticide containers (up to 23 L for plastic and 20 L for metal) can be returned to pesticide container depots located throughout the province.

To locate the pesticide container recycling depot closest to you, call the Ontario Pesticide Education Program at 1-800-652-8573.

### Paper and Cardboard Containers

Paper or cardboard containers are often rigid enough to withstand rinsing. If it is possible, triple rinse these containers as you fill the tank. After rinsing, empty containers can be taken to a landfill or burned.

Burn the containers in an isolated area on your farmland. Be very careful around the smoke. It may contain toxic fumes from the burning pesticide. Be certain that there is no chance that a person or animal may breathe in this smoke. Make sure that the smoke does not drift toward buildings, roads or any public outdoor areas.

These containers can also be taken to a local waste disposal site in the same way as metal, plastic or glass containers. If you can't dispose of them immediately, make sure containers are kept in a secure place such as the pesticide storage area.

### Unwanted Pesticides

If you have pesticides that you do not need or cannot use, be sure to dispose of them safely. Contact the supplier. It is sometimes possible to return unused pesticide if it is still in its original container.

If you cannot find any way to use the product as shown on the label, then the Ministry of the Environment and Energy requires that waste be disposed of by licensed waste haulers to a licensed waste disposal site. Look in the Yellow Pages of your telephone directory under "Liquid Waste Removal."

Watch your local paper for "Municipal Waste Collection Days" or contact your municipality. If your municipality has no waste collection days, encourage them to sponsor such an event. On these days, you can turn over surplus pesticide concentrates (maximum 25 L) for disposal.

Consult with the regional Ministry of the Environment and Energy Office for additional information. The Ministry of the Environment and Energy has an agreement with Safety-Kleen for the disposal of unwanted pesticides on a user-paid basis. Contact Safety-Kleen in London, Ontario, at (519) 451-6630, for disposal of unwanted or contaminated pesticides.

### Surplus Spray Mix

The best way to dispose of any excess spray mix is to find other fields that require an application of this pesticide. Before spraying, check the label to make sure the pesticide is registered for use on that crop.

If you can't find another field to spray, then dilute the remaining spray mix by adding 10 parts of water for each 1 part of spray mix. This diluted solution can be safely applied to the treated area as long as you do not exceed the pesticide rate recommended on the label. Be sure to check the label for any restrictions about crop rotation, days to harvest or surplus spray mix disposal.

NEVER re-spray the treated field with undiluted spray mix. Spraying an area twice will double the recommended pesticide rate. This may cause crop damage or illegal pesticide residues in the harvested crop.

## Pesticide Spills

**Protect yourself** before you begin to clean up any spill. Clean up spills immediately.

In the case of minor spills:

- for liquids, cover the spill with a thick layer of absorbent material such as kitty litter, vermiculite or dry soil. Sweep or shovel the material into a waste drum.
- for powders and granulars, sweep or shovel the material into a waste drum.

In the case of a major spill:

- remove any people or animals from the spill area
- stop the spill from spreading
- do not let the pesticide enter any watercourse.

**If a pesticide spill causes, or is likely to cause, an adverse effect, you must notify the Ministry of Environment and Energy Spills Action Centre at 1-800-268-6060 (24 hrs a day, 7 days a week) and the municipality.**

For information on preventing spills see the OMAF Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025.

If a well becomes contaminated, follow the clean-up instructions in the OMAF Factsheet, *Pesticide Contamination of Farm Water Supplies*, Order No 00-099.

# 2. Soil Fertility

For a complete guide to soil fertility, consult OMAF Publication 611, *Soil Fertility Handbook.*

Ontario currently uses about 690,000 tonnes of fertilizer annually. High yields can be produced efficiently only when fertilizer use is related to the fertility level of the soil. Additions of other nutrients (manure, crop residues and other organic sources) must also be taken into consideration. At one extreme, on very low-fertility soils, it is occasionally profitable to add as much nitrogen, phosphorus or potassium in the fertilizer as a crop removes. At the other extreme, on high fertility soils or following heavy application of manures, fertilizer may not be profitable and may occasionally reduce yield

## Assessing Nutrient Needs

1. The OMAF-accredited soil test is the most accurate tool available to Ontario farmers to determine the amounts of phosphorus, potassium, magnesium and lime that should be applied for crop production.
2. Plant analysis of vegetables is a tool that can provide additional information supporting the soil test.
3. Leaf symptoms are helpful in evaluating some nutrient deficiencies. However, by the time deficiency symptoms are visible, yield losses may have already occurred.
4. It is occasionally suggested that a grower apply the amounts of nutrients removed by the crop. This has some application for nitrogen (for some crops, the recommended rate approximates what the plant removes) but has little relevance for other nutrients in Ontario. Some Ontario clay and clay loam soils have sufficient potassium to last many years. Applying potassium each year on those soils is a waste of money (unless potassium plays a key role in the quality of that particular crop) and ignores one of the few advantages that clay soils have over coarser-textured soils.

Use the OMAF-accredited soil testing program along with plant analysis and evidence from nutrient deficiency symptoms as the main guide for determining fertilizer requirements for a specific crop on a specific field. See Table 2–1, *OMAF-Accredited Soil Tests,* right.

**Table 2–1.**
**OMAF-Accredited Soil Tests**

See Appendix D, *Accredited Soil-Testing Laboratories in Ontario,* on page 283, for a list of accredited labs in Ontario.

| Materials | What Is Analyzed[1] |
|---|---|
| Soils for field-grown crops, commercial turf, etc. | plant-available phosphorus, potassium, magnesium and zinc.<br>pH<br>lime requirement |
| Greenhouse media | plant-available nitrogen, phosphorus, potassium, calcium, magnesium<br>pH<br>total salts |
| Nutrient solutions, water | plant-available nitrogen, phosphorus, potassium, calcium, magnesium<br>pH<br>total salts<br>sulphates<br>chlorides |

[1] Soil organic matter tests can be useful for herbicide recommendations but are not accredited tests.

### Soil Testing

The OMAF-accredited soil testing program provides recommendations for nitrogen, phosphate, potash and magnesium fertilizer, as well as recommendations for the amount and type of lime to be applied. (See Table 2–1, above.)

The OMAF-recommended fertilizer rates are provided in this publication. They are designed to produce the highest economic yields when accompanied by good or above-average management.

Research shows that higher rates will occasionally produce higher yields. These increases in yield are likely to be small and not profitable. Some fertilizer is recommended at soil test levels slightly above those where crop response is profitable. This is done to maintain high soil nutrient levels and to allow for some error in sampling. In some cases, crop quality is also associated with the maintenance of high soil nutrient levels.

A soil test recommendation is affected by manure application, plowing down of legume sod and the type of crop to be fertilized. This information is essential for a reliable fertilizer recommendation and should be recorded on the field information sheet that must accompany the soil sample sent in for analysis.

### *Sampling*

Soils may be sampled with a soil probe or with a shovel. Each field or uniform section of a field should be sampled separately. For fields up to 5 ha (12 ac) in size, take at least 20 soil cores 15 cm deep. Take proportionately more cores for fields larger than 5 ha. The more cores taken, the more likely the soil sample is to provide a reliable measure of the fertility in the field. One sample should not represent more than 10 ha (25 acres).

Travel the area sampled in a zigzag pattern to provide a uniform distribution of sampling sites. Take a separate sample for any parts of a field that differ in appearance of soil or crop, in previous fertilization, manuring or liming, even if they are too small to fertilize separately. Avoid sampling recent fertilizer bands, dead furrows, areas adjacent to gravel roads or areas where lime, manure, compost or crop residues have been piled.

Collect the soil in a clean plastic pail. Break the lumps and mix the soil well before sending a soil sample for testing.

### *When to Sample*

Sample each field once every 2 or 3 years. Potash levels can change quickly where large amounts of nutrients are removed from sandy soils and are not returned (for example, with crops such as alfalfa hay, corn silage, potatoes or tomatoes). Under these conditions, take samples each year.

To allow time for mailing and analysis, take soil samples in the fall from fields to be fertilized for spring-seeded crops. Because of the rush of harvest and the frequency of poor weather late in the fall, it may be more convenient for some growers to sample in the summer. Take samples at the same time each year for more consistent sample results.

## Plant Analysis

Plant analysis measures the nutrient content of plant tissue. Comparing the results against the normal range of values for the crop can indicate whether nutrient supply is adequate for optimum growth.

Plant analysis is a useful supplement to soil testing. It can provide an evaluation of the fertility status of the crop, especially for phosphorus, potassium, magnesium and manganese. It has not been very reliable for nitrogen and zinc. There is no reliable soil test for boron and copper, so plant analysis and visual symptoms are used for diagnosing deficiencies.

### Soil Tests From Other Laboratories

**Each year, a number of farmers ask OMAF staff to interpret results from laboratories that are not accredited. Provided the other laboratory uses the identical test used by the OMAF-accredited service and expresses their test results in the same units, the OMAF fertilizer requirements for phosphate and potash can be determined.**

**Only OMAF-accredited soil tests can be relied on to provide accurate fertilizer recommendations. Be certain that the service you are using is accredited. To be accredited, a laboratory must use OMAF-approved testing procedures, must demonstrate acceptable analytical precision and accuracy and must provide the OMAF fertilizer recommendations.**

**A number of laboratories provide soil tests such as exchange capacity, aluminum and copper. These are not accredited by OMAF because they have not been found to contribute to better fertilizer recommendations. Research has shown that on Ontario soils, use of exchange capacity to adjust potash recommendations can lead to less reliable recommendations than are now provided.**

Plant analysis has limitations. Expert help in interpreting the results is often needed, since plant analysis does not usually indicate the cause of a deficiency or the amount of fertilizer required for correcting it.

### *Sampling*

Time of sampling has a major effect on the results of plant analysis since nutrient levels within a plant vary considerably with the age of the plant. Results are difficult to interpret if samples are taken at times other than those recommended. Nevertheless, plants that are suspected of being nutrient deficient should be sampled as soon as a problem appears. Samples are best taken from a problem area rather than from the entire field.

Samples for plant analysis should be taken from at least 20 plants distributed throughout the area chosen for sampling. Each sample should consist of at least 100 gm of fresh material. Sample problem areas separately. When taking samples for plant analysis, take care not to contaminate the sample with soil. Even a small amount of soil will cause the results to be invalid, especially for micronutrients.

### *Sample Preparation*

Samples of fresh plant material should be delivered directly to the laboratory. If they are not delivered immediately, they should be dried to prevent spoilage. Samples may be dried in the sun or in an oven at 65°C or less. Take precautions to prevent contamination with dust or soil. Avoid contact of samples with galvanized (zinc-coated) metal, brass or copper.

Plant analyses may be obtained from several laboratories in Ontario, see Appendix D, *Accredited Soil-Testing Laboratories in Ontario*, on page 283, for a list of laboratories providing plant tissue analysis.

### Micronutrient Tests

OMAF-accredited soil tests are available for manganese and zinc. To test for zinc deficiency on corn, the soil test is best used in conjunction with visual symptoms. With manganese, plant analysis, visual symptoms and the soil test are all useful.

OMAF-accredited tests are not available for boron, copper, iron or molybdenum. Plant analysis is generally a better indicator of deficiencies of these nutrients.

Great care is required to prevent contamination of soil samples with micronutrients, particularly zinc. Do not use galvanized (zinc-plated) soil sampling tubes to take soil samples for micronutrient tests. Do not use metal containers to collect and mix samples. Clean, plastic containers in good condition should be satisfactory. Soil samples that have contacted galvanized surfaces are unsatisfactory for zinc soil tests. Be careful to keep dust out of the samples.

Micronutrient deficiencies frequently occur in small patches in fields. In these cases, soil or plant analysis taken from the entire field is unlikely to find the problem. Sample problem areas separately.

## Soil pH and Liming

The pH scale ranging from 0 to 14 is used to indicate acidity and alkalinity. A pH value of 7.0 is neutral. Values below 7.0 are acid, and those above 7.0 are alkaline (basic). On mineral soils, most vegetable crops grow well in a soil pH range from 6.0 to 7.5. A range of 5.0 to 6.0 is acceptable on muck soils.

### Raising pH

Increase soil pH by broadcasting and incorporating ground limestone into the soil at rates determined by soil test. Table 2–2, *Soil pH at Which Lime Is Recommended for Ontario Field-Grown Crops*, right, shows the pH values below which lime is recommended and the target soil pH to which soils should be limed for different crops. In Ontario, most crops grow quite well at pH values higher than the target pH for which lime is recommended.

**Table 2–2.**
**Soil pH at Which Lime Is Recommended for Ontario Field-Grown Crops**

| Crop | Soil pH Below Which Lime Is Recommended | Target Soil pH[1] |
|---|---|---|
| **Coarse- and Medium-Textured Mineral Soils** (sands, sandy loams, loams and silt loams) | | |
| Perennial legumes, oats, barley, wheat, triticale, beans, peas, canola, flax, tomatoes, raspberries, strawberries, all other crops not listed below | 6.1 | 6.5 |
| Corn, soybeans, winter rye, grass hay and pasture, turf, tobacco | 5.6 | 6.0 |
| Potatoes | 5.1 | 5.5 |
| **Fine Textured Mineral Soils** (clay and clay loams) | | |
| Alfalfa, cole crops, rutabaga | 6.1 | 6.5 |
| Other perennial legumes, oats, barley, wheat, soybeans, beans, peas, canola, flax, tomatoes, all crops not listed below or above | 5.6 | 6.0 |
| Corn, rye, grass hay, pasture | 5.1 | 5.5 |
| **Organic Soils** (peats and mucks) | | |
| All field and vegetable crops | 5.1 | 5.5 |

[1] Where a crop is grown in rotation with other crops requiring a high pH (for example, potatoes in rotation with cole crops ), it is recommended that the soil be limed to the higher pH.

### Buffer pH

Different soils will require different amounts of lime to bring the pH to a particular desired level. The clay and organic matter content of each soil will affect how easily its pH is altered.

The soil pH is used to determine which soils need to be limed. A separate test, the buffer pH test, determines the amount of lime required. For soils needing lime (based on soil pH), Table 2–3, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, on page 12, indicates the amount of lime required to reach the different "target" soil pH values required for different crops.

### Limestone Quality

Calcitic limestone consists largely of calcium carbonate. Dolomitic limestone is a mixture of both calcium and magnesium carbonates. Dolomitic limestone should be used on soils with a magnesium soil test of 100 or less. It is an excellent and inexpensive source of magnesium for acid soils. Use either calcitic or dolomitic limestone on soils with magnesium tests greater than 100.

Two main factors affect the value of limestone for soil application. One of these is the amount of acid a given quantity of limestone will neutralize when it is totally dis-

### Table 2–3.
### Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH

Ground limestone required —
tonne/ha (based on Agricultural Index of 75)

| Buffer pH | Target soil pH = 7.0[1] | Target soil pH = 6.5[2] | Target soil pH = 6.0[3] | Target soil pH = 5.5[4] |
|---|---|---|---|---|
| 7.0 | 2 | 2 | 1 | 1 |
| 6.9 | 3 | 2 | 1 | 1 |
| 6.8 | 3 | 2 | 1 | 1 |
| 6.7 | 4 | 2 | 2 | 1 |
| 6.6 | 5 | 3 | 2 | 1 |
| 6.5 | 6 | 3 | 2 | 1 |
| 6.4 | 7 | 4 | 3 | 2 |
| 6.3 | 8 | 5 | 3 | 2 |
| 6.2 | 10 | 6 | 4 | 2 |
| 6.1 | 11 | 7 | 5 | 2 |
| 6.0 | 13 | 9 | 6 | 3 |
| 5.9 | 14 | 10 | 7 | 4 |
| 5.8 | 16 | 12 | 8 | 4 |
| 5.7 | 18 | 13 | 9 | 5 |
| 5.6 | 20 | 15 | 11 | 6 |
| 5.5 | 20 | 17 | 12 | 8 |
| 5.4 | 20 | 19 | 14 | 9 |
| 5.3 | 20 | 20 | 15 | 10 |
| 5.2 | 20 | 20 | 17 | 11 |
| 5.1 | 20 | 20 | 19 | 13 |
| 5.0 | 20 | 20 | 20 | 15 |
| 4.9 | 20 | 20 | 20 | 16 |
| 4.8 | 20 | 20 | 20 | 18 |
| 4.7 | 20 | 20 | 20 | 20 |
| 4.6 | 20 | 20 | 20 | 20 |

[1] Liming to pH 7.0 is recommended only for club-root control on cole crops.
[2] Add lime if soil pH is below 6.1.
[3] Add lime if soil pH is below 5.6.
[4] Add lime if soil pH is below 5.1.

solved. This is called the "neutralizing value" and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that will neutralize 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the higher the neutralizing value.

Particle size also affects the neutralizing value of limestone. Limestone rock has much less surface area to react with acid soil than finely powdered limestone. As a result, it neutralizes acidity much more slowly — so slowly that it is of little value. The calculation of a fineness rating for ground limestone is illustrated in Table 2–4, *Example Calculation of the Fineness Rating of Limestone*, right.

### Table 2–4.
### Example Calculation of the Fineness Rating of Limestone

| Particle Size | % of sample | | Effectiveness Factor | | |
|---|---|---|---|---|---|
| Coarser than No. 10 sieve[1] | 10 | X | 0.0 | = | 0 |
| No. 10 sieve to No. 60 sieve | 40 | X | 0.4 | = | 16 |
| Passing through No. 60 sieve[2] | 50 | X | 1.0 | = | 50 |
| | | | Fineness Rating | = | 66 |

[1] A No. 10 sieve has wires spaced 2.0 mm.
[2] A No. 60 sieve has wires spaced 0.25 mm apart.

## *The Agricultural Index*

The Agricultural Index compares the neutralizing ability of different limestone sources. It is a combination of the neutralizing value and the fineness rating. Limestone with a high Agricultural Index is worth proportionately more than limestone with a low index because it may be applied at a lower rate.

$$\boxed{\text{The Agricultural Index} = \frac{\text{neutralizing value x fineness rating}}{100}}$$

Recommendations from the OMAF-accredited soil tests are based on limestone with an Agricultural Index of 75. If the Agricultural Index is known, calculate a specific rate of application using the following equation:

$$\boxed{\begin{array}{c}\text{Limestone application rate}\\\text{from soil test}\end{array} \times \frac{75}{\begin{array}{c}\text{Agricultural Index}\\\text{of your limestone}\end{array}} = \begin{array}{c}\text{Rate of}\\\text{application}\\\text{of your}\\\text{limestone}\end{array}}$$

For example, assume the soil test recommends 9 t/ha of limestone. If the limestone source has an Agricultural Index of 90, the application rate should be 7.5 t/ha (9 x 75/90 = 7.5 t/ha). The Agricultural Index does not provide information about magnesium content.

## *Effect of Tillage Depth*

Lime recommendations presented in Table 2–3, left, should raise the pH of the top 15 cm (6 in.) of a soil to the listed target pH. If the soil is plowed to a lesser or greater depth than 15 cm, proportionately more or less lime is required to reach the same target pH. Where reduced tillage depths are used, rates of application should be reduced proportionately. However, more frequent liming will be needed.

## Lowering Soil pH

On soils with pH values below 6.5, it is possible to lower the pH (make the soil more acid) by adding sulphur or ammonium sulphate. This may be desirable for some crops, such as potatoes for scab control. However, it may not be suitable for rotation crops. A soil's pH cannot switch from a low pH to a more moderate pH annually. If the soil pH is above 6.5, it is not practical to lower the soil pH because very large amounts of sulphur or ammonium sulphate will be required.

## Fertilizer Recommendations

**Changes in Crop or Management**

**Fertilizer requirements on the OMAF soil test report are for specific crops and management. Adjustments in fertilizer requirements may be needed if changes are made in manure applications or if legumes are incorporated. For fertilizer adjustments, see Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19. Changing the crop from the original soil test recommendation will require a new fertilizer recommendation. This can be obtained by referring to Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, or Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, or Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.**

### Nitrogen

Nitrogen fertilizer recommendations for vegetable crops are based on estimated crop requirements. Recommended rates are presented under the heading *Fertility* in the sections on individual crops in Chapter 6, *Crop Management Recommendations*. Rates should be decreased if manure is applied or if the previous crop contained perennial legumes such as alfalfa (see *Changes in Crop or Management*, above).

To protect crop quality and avoid surface and groundwater pollution, the combined application of fertilizer, manure, and other sources of nitrogen should not supply more plant-available nitrogen than the crop requires.

### Phosphate and Potash

Phosphate and potash recommendations in this publication are based on Ontario Ministry of Agriculture and Food–accredited soil tests. Crop-specific recommendations are outlined in Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15. These tables should only be used with OMAF-accredited soil tests. Non-accredited tests may use extractants that remove different amounts of nutrients, resulting in inaccurate recommendations if used with the OMAF tables.

Where a soil test is not available, a rough estimate of requirements can be obtained from these tables using the following guidelines:

- If the field has been fertilized regularly for a number of years or heavily in recent years, use one of the rates of phosphate and potash recommended for the MEDIUM soil test rating.
- If the field has received little fertilizer in the past, use one of the rates recommended for a LOW soil test rating.

Soils testing excessive (E) for phosphorus contain much more plant-available phosphorus than required for most crops. The risk of surface water contamination by phosphorus may be increased at higher soil test phosphorus levels. Phosphorus binds tightly to soil particles. As a result, the movement of soil off the field through erosion is also a major factor in determining the risk of surface water contamination.

Wherever soil test results are "very high" or "excessive," applications of any source of phosphorus (manure, fertilizer, processing plant refuse, etc.) should be guided by a "phosphorus index." The phosphorus index ranks the relative risk of surface water contamination for applications made to a particular piece of land. It will also determine the maximum application rates if manure is applied and the required separation distance from watercourses. For more information, refer to the OMAF Factsheet, *Determining the Phosphorus Index for a Field*, Order No. 98-079.

Some clay and clay loam soils are naturally high in potassium and do not require any potash fertilizers. Only a soil test can adequately determine potash requirements.

### Magnesium

Magnesium is a plant nutrient that is naturally plentiful in many Ontario soils. Soils with OMAF magnesium soil test results below 20 require magnesium application for the production of most crops. Very few Ontario soils have magnesium tests below 20.

If the soil pH is below 6.0, the most effective and inexpensive means of supplying magnesium is by the application of dolomitic lime. If the pH is above 6.0, and the soil test 20 or below, magnesium can be supplied by either magne-

## Table 2–5.
## Phosphorus Requirements: Vegetables on Mineral Soils

| Phosphorus Soil Test (ppm P in soil) | Rating | Phosphate ($P_2O_5$) Required kg/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Beans (lima & snap), Peas | Radishes | Sweet Corn, Asparagus (established) | Sugarbeets | Beets, Carrots, Lettuce, Onions, Parsnips, Rutabagas, Spinach, Horseradish | Potatoes | Cucumbers, Muskmelons, Pumpkins, Squash, Tomatoes[1], Watermelons | Celery, Rhubarb | Broccoli[2], Brussels sprouts[2], Cabbages[2], Cauliflower[2], Eggplant[1], Peppers[1], Asparagus (nursery & new plantings) |
| 0–3 | Low | 80 | 80 | 110 | 150 | 180 | 200 | 230 | 230 | 270 |
| 4–5 | | 60 | 70 | 100 | 140 | 170 | 200 | 230 | 230 | 260 |
| 6–7 | | 50 | 60 | 90 | 140 | 170 | 190 | 220 | 220 | 250 |
| 8–9 | | 40 | 60 | 70 | 130 | 160 | 190 | 220 | 220 | 240 |
| 10–12 | Medium | 30 | 50 | 50 | 130 | 160 | 180 | 210 | 220 | 230 |
| 13–15 | | 20 | 50 | 20 | 120 | 150 | 170 | 190 | 210 | 220 |
| 16–20 | High | 0 | 40 | 20 | 100 | 140 | 160 | 170 | 190 | 200 |
| 21–25 | | 0 | 40 | 20 | 90 | 120 | 140 | 140 | 160 | 170 |
| 26–30 | Very High | 0 | 30 | 20 | 70 | 100 | 120 | 110 | 140 | 140 |
| 31–40 | | 0 | 30 | 0 | 50 | 80 | 90 | 80 | 110 | 110 |
| 41–50 | | 0 | 20 | 0 | 30 | 50 | 50 | 50 | 80 | 80 |
| 51–60 | | 0 | 0 | 0 | 0 | 30 | 30 | 30 | 50 | 50 |
| 61–80 | Excessive | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| 80+ | | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 |

[1] For transplanted tomatoes, peppers and eggplants, apply a starter solution, such as 1 L of 10-34-0 per 100 L of water, or 1 L of 6-24-6 per 75 L at planting.

[2] For transplanted broccoli, Brussels sprouts, cabbages and cauliflower, if no insecticide is used in the planting water, apply a starter solution high in nitrogen such as 20-20-20 at 1 kg/200 L. Under high temperatures and in dry, sandy soils, use half the concentration of fertilizer.

sium sulfate or sulfate of potash magnesia. Apply 30 kg/ha of actual soluble magnesium. These latter sources of magnesium are usually quite expensive compared to supplying magnesium from dolomitic limestone.

Potassium competes with magnesium for uptake by the crop. Excessive potash applications can induce a magnesium deficiency. For this reason, it is important to monitor soil potassium levels and to carefully control potash fertilizer applications on low magnesium soils.

A magnesium deficiency may occur on carrots, celery, tomatoes and spinach. The usual symptom is yellowing of the older leaves while the veins remain dark green. Potato plants may become lighter in colour.

For magnesium application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Calcium

Calcium deficiencies rarely occur in vegetables grown on soils with a pH of 6.0–7.5. Calcium-related disorders may occur in some crops (e.g., blossom end rot in tomatoes, blackheart in celery or tipburn in lettuce and cabbage.) These problems are caused by difficulties in transporting calcium through the plant, usually resulting from insufficient water.

Several cultural management practices will reduce the occurrence of calcium-related disorders. Efficient nitrogen use will help prevent excessive vegetative growth. Good soil management practices ensure adequate root volume and promote both water and nutrient uptake. Timely irrigation will help prevent calcium shortages in the plant. For calcium application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Table 2–6.
## Potassium Requirements: Vegetables on Mineral Soils

| Potassium Soil Test (ppm K in soil) | Rating | Potash ($K_2O$) Required kg/ha | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Radishes | Beans (snap & lima), Peas | Sweet Corn | Sugarbeets | Tomatoes (paste & fresh market), Cucumbers, Muskmelons, Pumpkin, Squash, Watermelons | Beets, Carrots, Lettuce, Onions, Parsnips, Potatoes, Spinach, Horseradish | Broccoli, Brussels sprouts, Cabbages, Cauliflower, Eggplant, Peppers | Celery, Rhubarb, Rutabagas[1] | Asparagus | Tomatoes[1] (whole pack) |
| 0–15 | Low | 60 | 120 | 170 | 180 | 230 | 230 | 270 | 340 | 420 | 660 |
| 16–30 | | 60 | 110 | 160 | 170 | 220 | 220 | 250 | 330 | 400 | 640 |
| 31–45 | | 50 | 90 | 140 | 160 | 200 | 210 | 230 | 310 | 360 | 600 |
| 46–60 | | 50 | 80 | 110 | 140 | 180 | 190 | 200 | 280 | 320 | 560 |
| 61–80 | Medium | 40 | 60 | 80 | 120 | 140 | 160 | 170 | 250 | 280 | 480 |
| 81–100 | | 30 | 40 | 50 | 90 | 100 | 130 | 130 | 200 | 250 | 400 |
| 101–120 | | 30 | 30 | 30 | 70 | 70 | 100 | 100 | 150 | 220 | 340 |
| 121–150 | | 20 | 0 | 0 | 20 | 50 | 80 | 80 | 90 | 190 | 300 |
| 151–180 | | 20 | 0 | 0 | 0 | 40 | 50 | 50 | 50 | 160 | 280 |
| 181–210 | High | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 130 | 140 |
| 211–250 | Very High | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 70 |
| 250+ | Excessive | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[1] For rutabagas and tomatoes on soils with magnesium tests less than 100, the required amount of potash is adjusted downward from the amounts shown in this table to a minimum of 50% at 50 ppm Mg.

## Table 2–7.
## Phosphorus and Potassium Requirements: Vegetables on Muck Soils

| Phosphorus | | | | | Potassium | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Phosphate required kg $P_2O_5$/ha | | | | | Potash required kg $K_2O$/ha | | |
| Phosphorus Soil Test ppm P in soil | Rating | Beets<br>Broccoli<br>Brussels sprouts<br>Cabbages<br>Carrots<br>Cauliflower | Lettuce<br>Onions[1]<br>Parsnips<br>Potatoes<br>Radishes<br>Spinach | Celery | Potassium Soil Test ppm K in soil | Rating | Broccoli<br>Brussels sprouts<br>Cabbages<br>Cauliflower | Carrots<br>Celery<br>Onions<br>Parsnips<br>Potatoes | Beets<br>Lettuce<br>Radishes<br>Spinach |
| 0–3 | Low | 100 | | 120 | 0–15 | Low | 200 | 230 | 100 |
| 4–5 | | 100 | | 120 | 16–30 | | 190 | 220 | 100 |
| 6–7 | | 100 | | 120 | 31–45 | | 170 | 210 | 90 |
| 8–9 | | 100 | | 120 | 46–60 | | 150 | 200 | 80 |
| 10–12 | Medium | 90 | | 120 | 61–80 | Medium | 120 | 170 | 60 |
| 13–15 | | 90 | | 110 | 81–100 | | 90 | 150 | 40 |
| 16–20 | | 80 | | 100 | 101–120 | | 70 | 120 | 30 |
| 21–25 | | 70 | | 90 | 121–150 | | 50 | 80 | 20 |
| 26–30 | | 60 | | 80 | 151–180 | | 40 | 40 | 20 |
| 31–40 | High | 50 | | 70 | 181–210 | High | 0 | 0 | 0 |
| 41–50 | | 30 | | 50 | 211–250 | Very High | 0 | 0 | 0 |
| 51–60 | Very High | 20 | | 40 | 250+ | Excessive | 0 | 0 | 0 |
| 61–80 | Excessive | 0 | | 0 | | | | | |
| 80+ | | 0 | | 0 | | | | | |

[1] If maturity of onions is a problem on organic soils less than 40 cm deep, additional phosphate may be required.

## Table 2–8.
## Application Rates for Magnesium, Calcium and Micronutrients

| | Soil Applied[1] | | | | Foliar Applied | |
|---|---|---|---|---|---|---|
| **Nutrient** | **Nutrient kg/ha** | **Product kg/ha** | **Source** | **% Composition** | **Nutrient kg/1,000 L** | **Product kg/1,000 L** |
| Calcium (Ca)[2] | – | – | calcium chloride | 36% Ca | 1.9 | 5.0 |
| | – | – | calcium nitrate | 19% Ca | 1.9 | 10.0 |
| Magnesium (Mg) | 120–260 | 2 t/ha | dolomitic limestone | 6–13% Mg | – | – |
| | 30 | 300 | epsom salts | 10.5% Mg | 1.9 | 18 |
| | 30 | 300 | sulphate of potash magnesia | 11% Mg | – | – |
| Boron (B) | 1.0–3.0 | | various materials available | 12–21% B | 0.1–0.3 | – |
| Copper (Cu) | 7.0–14.5 | 28–60 | copper sulfate | 13–25% Cu | 0.5–1.5 | 2–6 |
| | – | | copper chelates | 5–13% Cu | 0.5–1.5 | – |
| Manganese (Mn)[3] | – | – | manganese sulfate | 28% Mn | 0.5–1.0 | 1.8–3.6 |
| | – | – | manganese chelates | 5–12% Mn | 0.5–1.0 | – |
| Molybdenum (Mo) | – | – | sodium molybdate | 39% Mo | 0.1–0.25 | 0.25–0.6 |
| Zinc (Zn) | 4–14 | 11–33 | zinc sulfate | 36% Zn | 0.6 | 1.6 |
| | 4–14 | – | zinc oxysulfate | 18–36% Zn | – | – |
| | – | – | zinc chelate | 9–14% Zn | 0.6 | – |

[1] Double rates for muck soil, except dolomitic limestone.

[2] For blackheart of celery.

[3] For onions use 1.5 to 2.75 kg Mn/1,000 L.

## Micronutrients

Crops vary greatly in how they respond to applications of micronutrients. Highly responsive crops will often respond to additional micronutrients **if** the micronutrient concentration of the soil is low. Medium responsive crops are less likely to respond and low responsive crops do not usually respond to fertilizer additions even at the lowest soil micronutrient levels.

Table 2–9, *Response of Crops to Micronutrient Fertilizers*, on page 17, outlines the response of various vegetable crops to micronutrient fertilizers. It is important to note that a high rating does not mean the crop always needs additional micronutrients. Response to any given nutrient only occurs when the soil is already low in that nutrient.

Micronutrient elements should not be combined with insecticide, fungicide or herbicide sprays unless the manufacturer's directions indicate that this may be done or experience has shown that they are compatible.

Mixtures or concentrations of micronutrients in the starter fertilizer may cause phyto-toxicity, especially in adverse weather conditions. For micronutrient application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, above.

### *Boron*

Boron should be used with care. There is a fine line between adequate and toxic levels. Take all crops in the rotation into consideration when applying boron. Some crops are more sensitive and experience toxicity at lower levels. On some soils, boron is required for rutabagas, carrots, celery, beets, spinach and cole crops. Boron deficiencies often occur during dry weather. However, the response to boron is often inconsistent. As a result, it has not been possible to develop a reliable soil test. Visual symptoms and tissue analysis are useful for predicting boron requirements in plants.

A lack of boron causes a breakdown of the young tissue resulting in slow growth, tissue cracking, internal blackening and misshapen plants. In addition, the leaves of beets and spinach become twisted with light spots on the petioles. Internal breakdown (black spot) may occur in the roots or appear on the root surface as external cankers.

Broccoli and cauliflower show leaf rolling, deformed buds, hollow stems and brown heads. Cabbage develops internal dead spots and hollow stems. Celery petioles show reddish-brown spots called "cat-scratches." Rutabagas develop water-soaked internal areas known as "water-core."

Application of boron to mineral soils has not been universally successful. Foliar sprays generally give faster and more effective results. Spray when the young plants are about 8 cm high. A second application may be required.

On request, manufacturers may mix boron fertilizers with ordinary fertilizers. **Do not band boron.** Consult Table 2–8, *Application Rates for Magnesium, Calcium and*

### Table 2–9.
### Response of Crops to Micronutrient Fertilizers[1]

| Crop | Mn | B | Cu | Zn | Mo | Fe |
|---|---|---|---|---|---|---|
| Asparagus | Low | Low | Low | Low | Low | Med |
| Beans, snap | High | Low | Low | High | Med | High |
| Beets, table | High | High | High | Med | High | High |
| Broccoli | Med | High | Med |  | High | High |
| Cabbages | Med | Med | Med | Low | Med | Med |
| Carrots | Med | Med | Med | Low | Low |  |
| Cauliflower | Med | High | Med |  | High | High |
| Celery | Med | High | Med |  | Low |  |
| Cucumbers | High | Low | Med |  |  |  |
| Lettuce | High | Med | High | Med | High |  |
| Oats | High | Low | High | Low | Low | Med |
| Onions | High | Low | High | High | High |  |
| Parsnips | Med | Med | Med |  | Low |  |
| Peas | High | Low | Low | Low | Med |  |
| Peppers | Med | Low | Low |  | Med |  |
| Potatoes | High | Low | Low | Med | Low |  |
| Radishes | High | Med | Med | Med | Med |  |
| Rye | Low | Low | Low | Low | Low | Low |
| Spinach | High | Med | High | High | High | High |
| Sugarbeets | High | Med | Med | Med | Med | High |
| Sweet corn | High | Med | Med | High | Low | Med |
| Tomatoes | Med | Med | High | Med | Med | High |
| Turnips | Med | High | Med |  | Med |  |

Mn = Manganese B= Boron Cu = Copper
Zn = Zinc Mo = Molybdenum Fe = Iron

[1] Taken, with permission, from the Michigan State University Cooperative Extension Publication E486 *Secondary and Micronutrients for Vegetables and Field Crop* (Table 3, *Relative response of selected crops to micronutrient fertilizers.*)

*Micronutrients*, on page 16, for the rates required to correct a boron deficiency.

## Copper

Copper soil tests are quite unreliable on Ontario soils, but plant analysis is useful. Copper is unlikely to be deficient on mineral soil, except perhaps on very sandy soils. Copper deficiency does occur on organic soils and is best diagnosed by plant analysis.

Lettuce leaves that are deficient in copper lose their firmness. This is referred to as being "rabbit-eared." The plants become bleached on the stems and leaf margins. Copper-deficient onions produce thin, pale yellow scales. Affected onions have poor colour and decreased storage life. A lack of copper also causes poor colour in carrots.

Extreme care is necessary using foliar sprays with copper sulphate, as foliage is easily injured. See Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16, for rates and sources of copper fertilizers.

### Table 2–10.
### Manganese Availability Index

| Manganese Soil Test[1] | Suggested Treatments |
|---|---|
| Greater than 30 | Adequate for most crops |
| 15 to 30 | Adequate for most crops |
| Less than 15 | Likely insufficient for onions, lettuce, beets |
| Less than 8 | Soil test is quite low but deficiency is not expected in crops other than onions, lettuce, beets |

[1] These values are indices of manganese availability based on extractable soil manganese and soil pH.

When organic soils are first brought into cultivation, copper should be applied to the soil at 14 kg copper/ha for each of the first 3 years. Subsequent applications of 5 kg copper/ha should be applied every second year thereafter. Addition of copper to muck soils helps to slow down the subsidence of the soil. See the section *Subsidence of Peat and Muck Soils*, on page 23.

## Manganese

Manganese deficiency usually appears as yellowing between the leaf veins. It begins in the younger foliage and may eventually affect the whole plant. Beet symptoms include russetting, curling and dwarfing of the foliage. Beans, lettuce, celery and onions are also susceptible to manganese deficiency.

Manganese is less available at high soil pH, so it is important not to add more lime than is needed to correct soil acidity. For critical soil test ranges, see Table 2–10, *Manganese Availability Index*, above. This OMAF-accredited index indicates the availability of manganese related to the soil pH.

Foliar applications of manganese have proven to be more effective than soil applications. Apply sprays when the plants are about one-third grown or sooner, if this deficiency is identified. Two or more sprays may be necessary at 10-day intervals. Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16, lists the sources and rates for manganese fertilizers.

## Molybdenum

Molybdenum deficiency symptoms on cole crops start with cupping of the leaf margins and yellowing between the veins of the younger leaves. As the leaves develop, twisting of the midrib and irregular development of the leaf tissue cause a strap- or whiplike appearance known as "whiptail."

In other crops, the early symptoms of molybdenum deficiency are similar to nitrogen deficiency. Later symptoms are interveinal mottling of leaves with chlorotic areas

**Table 2–11.**
**Zinc Soil Index Interpretation**

| Zinc Soil Index[1] | Suggested Treatments |
|---|---|
| Greater than 200 | Contamination of the sample or of the field is likely. |
| 25 to 200 | Soil zinc availability is adequate for most field-grown crops. |
| 15 to 25 | Zinc availability is adequate for most field crops but is bordering on deficiency for corn. If the field sampled is uneven in soil texture, pH or erosion, some areas may respond to zinc applications. Deficiency symptoms at the 4-to-6 leaf stage are a reliable indication of zinc deficiency. |
| Less than 15 | Zinc is likely to be deficient for corn and should be applied in the fertilizer. |

[1] These values are indices of zinc availability based on extractable soil zinc and soil pH.

becoming puffy, marginal cupping and scorching of leaves and twisting and distortion of younger leaves.

This deficiency occurs more often on sandy, acid soils. Molybdenum availability to plants increases with an increase in pH. Consequently, liming acid soil may be a good practice to overcome molybdenum deficiency. Deficiency may occur even in neutral soils if heavy cropping has depleted soil molybdenum reserves.

For recommended molybdenum fertilizer rates, Refer to Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16. Molybdenum can also be applied in the transplanting water at the rate of 30–40 g of sodium molybdate per 100 L of water, each plant receiving 0.3 L of this solution.

### *Zinc*

Corn and onions may show zinc deficiency in Ontario. Zinc deficiency has been reported in beans in other areas but appears to be rare in Ontario. High phosphorus in the soil and/or in the fertilizer can cause or increase the severity of zinc deficiency. Apply only the recommended amount of phosphorus. Use of animal manures can prevent or reduce zinc deficiency.

Zinc deficiency can be prevented by the application of zinc fertilizer to the soil at a rate of 4 kg Zn/ha. Up to 14 kg Zn/ha can be broadcast, which will correct a deficiency for 3 years. No more than 4 kg Zn/ha should be banded. Early in the growing season, foliar sprays can be used to correct a deficiency after the symptoms have appeared. Table 2–11, *Zinc Soil Index Interpretation*, above, relates zinc availability with soil pH. For zinc application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

**Table 2–12.**
**Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down**

| Type of Sod | For All Crops, Deduct From N Requirement kg N/ha |
|---|---|
| Less than ⅓ legume | 0 |
| ⅓ to ½ legume | 55 |
| ½ or more legume | 100 |
| Perennial legumes seeded and plowed the same year | 45[1] |
| Soybean and field bean residue | 0 |

[1] Applies where the legume stand is thick and over 40 cm high.

## Adjustments to Fertilizer Recommendations

### Adjustments for Legumes Plowed Down

When sod containing perennial legumes such as alfalfa, trefoil and clover are plowed under, they supply an appreciable amount of nitrogen to the following crop. Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, above, shows reductions that should be made in nitrogen applications to crops following sod containing legumes.

### Manure

A large number of Ontario farms produce livestock, generating over 33 million tonnes of manure per year. Proper management of the nutrients from manure is essential for optimum economic benefit to the farmer with minimal impact on the environment.

#### *The Value of Manure*

The value of manure in crop production is often underestimated. In addition to nitrogen, phosphorus and potash, manure contains many secondary nutrients and micronutrients. However, they are not necessarily in the proportions needed for specific crop conditions. See Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.

Manure also contains valuable organic matter that helps to build and maintain soil structure.

#### *Long-Term Value of Manure*

The long-term availability of phosphorus (P), potassium (K), magnesium, zinc or manganese from previous manure applications is best estimated by soil testing. The application of large quantities of manure over time can result in high levels of available phosphorus and potassium in soils. Manure also contributes other plant nutrients and organic matter to soil that may be of some long-term value.

### Table 2–13.
### Average Amounts of Available Nutrients for Different Types of Manure

Nutrient values based on average analysis results for over 700 samples. There are large variations between different manures, so a manure analysis is your best guide to nutrient availability.

| Manure | Average Dry Matter | Available Nitrogen[1] Spring 1 day | Available Nitrogen[2] Spring not incorp. | Available $P_2O_5$[3] | Available $K_2O$[4] |
|---|---|---|---|---|---|
| | | kg/1,000 L (lb/1,000 gal) | | | |
| Liquid dairy | 6.5% | 1.6 (16) | .6 (6) | .7 (7) | 3 (30) |
| Liquid hog | 3.6% | 2.6 (26) | .7 (7) | 1.1 (11) | 2 (20) |
| Liquid poultry | 8.0% | 6.1 (61) | 1.7 (17) | 2.5 (25) | 3.4 (34) |
| | | kg/tonne (lb/ton) | | | |
| Solid biosolids | 36% | 1.5 (3) | 0.75 (1.5) | 11 (22) | 0 (0) |
| Solid poultry | 49% | 11.5 (21) | 6 (12) | 9 (18) | 12.5 (25) |
| Solid dairy | 20% | 1.5 (3) | 0.7 (1.4) | 1.5 (3) | 5.5 (11) |
| Solid beef | 27% | 1.5 (3) | 0.75 (1.5) | 1.5 (3) | 7 (14) |

[1] Nitrogen based on spring application, incorporated within 24 hours.
[2] Nitrogen based on spring application, not incorporated (i.e., on soil surface for over 7 days).
[3] Phosphate from manure or biosolids is assumed to be 40% as available as that in manufactured fertilizer in the year of application.
[4] Potash from manure or biosolids is assumed to be 90% as available as that in manufactured fertilizer in the year of application.

Fifty to sixty per cent of the nitrogen available in manure is used by the crop or is lost during the first growing season following application. The remaining organic nitrogen becomes available in small, diminishing quantities in the succeeding years. The amount of nitrogen left over from a previous year's application is usually too small to make a practical difference in nitrogen recommendations for a crop. However, where manure is applied regularly to the same field, there can be significant residual nitrogen available for a crop.

### Manure Analysis

The quantities of nutrients contained in manure vary from farm to farm, especially the phosphorus and potash components. The type of livestock, ration, bedding, added liquids and storage system all affect the final nutrient analysis.

A manure analysis is available from several laboratories in Ontario. See Appendix D, *Accredited Soil-Testing Laboratories in Ontario*, on page 283. An analysis should be performed after complete agitation or thorough mixing, each time the storage is emptied (e.g., spring and fall) or each time a new source is used. After several analyses of a particular manure source, a trend in the results will be evident, and sampling can be limited to major changes in ration or other management factors.

When submitting a sample for analysis, fill a 2-L plastic jar half-full, cover, and place in a plastic bag and store in a cool place until shipping. Analysis should include total nitrogen, ammonium-nitrogen ($NH_4$-N), phosphorus, potassium and dry matter. Ontario labs send back analysis results with percentages for nitrogen, phosphorus, potassium and dry matter as well as mg/kg (or ppm) of ammonium-nitrogen. Percentages for phosphorus and potassium from manure are converted to commercial $P_2O_5$ and $K_2O$ equivalents and commercial fertilizer reductions are given. Table 2–13, above, summarizes average amounts of nutrients for different types of manure.

### Application

Soil test results and yield goals will determine the maximum economic application rate and/or additional fertilizer requirements. If manure is applied to meet the entire nitrogen requirements of a corn crop, there is usually more P and K applied than the crop will remove, and soil test levels will increase.

For liquid manure, an application goal of two-thirds to three-quarters of the nitrogen requirements for a corn crop is a reasonable compromise. The release of nitrogen is much less predictable with solid manure because of the high carbon content of the bedding material.

Soil compaction is a problem for many farmers. It leads to, among other things, poor drainage and decreased aeration. The best way to reduce or avoid soil compaction is to spread manure when the soil is dry. Loads should be kept below about 5 tons per axle. These points should be considered in the selection of spreading equipment and in the timing of spreading (i.e., summer vs. spring vs. fall application). Spring spreading is often carried out on fields that are too wet, and it is not unusual for strips of stunted crops to serve as an indicator of the wheel track locations.

**See OMAF Publication 611, *Soil Fertility Handbook*, for more detailed information on manure and nutrient values.**

### *Environmental Concerns*

Always take care to avoid manure contamination of surface and groundwater sources. If manure is applied to unprotected cropland, nitrogen can be carried off-site by rainwater. Phosphorus-rich soil particles can be carried to streams by soil erosion. Soil conservation practices can reduce the chances of nutrients polluting waterways.

Groundwater contamination can occur by mass flow through cracks and holes to groundwater or through leaching of nitrates through the soil. Shallow soils over bedrock, soils with a water table close to the surface and very sandy soils are of particular concern.

Spreading manure in the winter and early spring is not recommended because of the potential for run-off to surface water. In years when winter spreading may be necessary, take care to select fields where there is minimal risk of run-off to surface water.

Liquid manure should not be spread within 10 m (33 ft) of a watercourse. Solid manure should have a 5 m (16 ft) buffer zone.

Tile drain effluent can become contaminated if manure enters a catch-basin or travels through soil cracks to the tiles. With liquid manure, maintain a 10-m (33-ft) buffer around a catch-basin or surface inlet. Use a 5-m (16-ft) buffer with solid manure. Tillage prior to application of liquid manure is recommended.

### *Food Safety Concerns*

Fruit and vegetable crops can become contaminated in the field if they contact microbes that cause human illness. These microbes can come from manure and manure-based composts. They can contaminate fruit or vegetables by direct soil-to-produce contact or through rain-splashed soil. Examples of harmful microbes are some, but not all, strains of *E. coli, Salmonella* and *Campylobacter.*

The longevity of harmful microbes in manure is not well known. Proper composting of manure, which results in heating to a specific temperature for a specified period of time, will reduce the level of most pathogens. Aged manure (manure stored in piles and occasionally turned) may contain considerably more pathogens than properly composted manure (manure turned/mixed frequently, temperature monitored and maintained).

Composting may not completely eliminate all pathogens, so the appropriate precautionary measures should be taken when manure is used. Incorporation of manure will minimize but may not eliminate the risk of microbial contamination of produce. For more information on food safety concerns in vegetable crops, see the section *Food Safety*, on page 37.

## Biosolids

Biosolids from off-farm sources can be a useful source of nutrients and organic matter. Guidelines are available from OMAF and the Ministry of the Environment and Energy (MOEE). A Certificate of Approval for land application is required and is available from MOEE. An analysis of nutrients applied should be given by the applicator to the landowner whenever biosolids are applied. Sewage sludge from municipal sewage treatment plants may not be applied to vegetable-producing land within 12 months of harvest.

……

## Fertilizer Materials

Nitrogen fertilizer materials are available in dry or liquid forms. Although there are some limitations to the use of these materials (see the section *Toxicity of Fertilizer Materials*, on page 21), in most cases, the different sources will produce equal yields. The grower's choice of material should therefore depend on availability, equipment for handling and cost per kilogram of nitrogen, plus the cost of application.

The nitrogen recommendations in the commodity sections of Chapter 6, *Crop Management Recommendations*, are measured in kilograms of elemental nitrogen (N), not kilograms of materials. Table 2–14, *Fertilizer Materials: Primary Nutrients*, and Table 2–15, *Fertilizer Materials: Secondary and Micronutrients*, on page 21, show the percentage of elemental nutrient contained in different materials.

In addition to the micronutrient sources listed in Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16, various fertilizer companies sell pre-mixes containing one or more micronutrients.

## Soluble Salts in Farm Soils

High concentrations of water-soluble salts in soils can prevent or delay germination of seeds. They can also kill established plants or seriously retard their growth.

Ontario field soils are naturally low in soluble salts. Soluble salts therefore rarely cause a problem in crop production and are not routinely measured in soil tests. Vegetable transplants, however, routinely experience salt problems. Some direct-seeded crops can also experience salt problems, usually resulting from fertilizer management practices. Symptoms resemble damping-off and/or uneven seedling growth.

Soluble salts in soils can result from excessive applications of fertilizers and manures, run-off of salts applied to roads

### Table 2–14.
### Fertilizer Materials:
### Primary Nutrients

| Nitrogen Materials | Form | % Nitrogen (N) |
|---|---|---|
| Ammonium nitrate | Dry | 33 to 34 |
| Urea | Dry | 45 to 46 |
| Ammonium sulfate | Dry | 20 |
| Calcium ammonium nitrate | Dry | 27 |
| Calcium nitrate | Dry | 15.5 |
| Aqua ammonia | Liquid[1] | 20 |
| Urea ammonium nitrate (UAN) | Liquid | 28 |
| Anhydrous ammonia | Liquid[1] | 82 |
| **Phosphate Materials** | | **% Phosphate ($P_2O_5$)** |
| Single superphosphate | | 20 |
| Triple superphosphate | | 44 to 46 |
| Monoammonium phosphate | | 48 to 52 |
| Diammonium phosphate (18-46-0) | | 46 |
| **Potash Materials** | | **% Potash ($K_2O$)** |
| Muriate of potash | | 60 to 62 |
| Sulfate of potash | | 50 |
| Sulfate of potash magnesia (11%Mg) | | 22 |
| Potassium nitrate (13-0-44) | | 44 |

[1] Liquid under pressure.

### Table 2–15.
### Fertilizer Materials:
### Secondary and Micronutrients

A number of micronutrients are available as chelates, with various formulations and nutrient contents. Check the product labels. The effective use rate for chelated products is the same as for other formulations.

| **Calcium (Ca)** | |
|---|---|
| Calcium chloride | 36% Ca |
| Calcium nitrate | 19% Ca |
| Liming materials and gypsum also supply calcium | variable % |
| **Magnesium (Mg)** | |
| Dolomitic limestone | 6%–13% Mg |
| Epsom salts (magnesium sulfate) | 10.5% Mg |
| Sulfate of potash magnesia | 11% Mg |
| **Boron (B)** | |
| Sodium borate | 12%–21% B |
| **Copper (Cu)** | |
| Copper sulfate | 13%–25% Cu |
| Copper chelates | 5%–13% Cu |
| **Manganese (Mn)** | |
| Manganese sulfate | 28% Mn |
| **Molybdenum (Mo)** | |
| Sodium molybdate | 39% Mo |
| **Zinc (Zn)** | |
| Zinc sulfate | 36% Zn |
| Zinc chelates | 9%–14% Zn |
| Zinc oxysulfate | 18%–36% Zn |

and chemical spills on farmland. High concentrations of soluble salts in or near a fertilizer band can cause serious early plant growth problems without seriously affecting the salt concentrations in the remainder of the soil. A given amount of salt in a soil provides a higher salt concentration in soil water if the amount of water is small. Soluble salts also interfere with the uptake of water by plants. For these reasons, plant growth is most affected by soluble salts in periods of low moisture supply (during drought periods).

Soluble salts can be measured readily in the laboratory by measuring the electrical conductivity of a soil water slurry. The higher the concentration of water-soluble salts, the higher the conductivity. Table 2–16, *Soil Conductivity Reading Interpretation*, on page 22, provides an interpretation of soil conductivity reading as read in Ontario field soils in the 2:1 (water:soil paste) procedure used by the OMAF-accredited soil testing program.

## Toxicity of Fertilizer Materials

All fertilizer salts are toxic to germinating seeds and to plant roots if applied in sufficient concentration near the seed. Fertilizers vary in toxicity per unit of plant nutrient due to:

- differences in the amount of salts contained in the fertilizer per unit of plant nutrient
- differences in solubility of the salts in the soil
- specific toxicity — a few specific materials or elements are particularly toxic (for example, ammonia and boron).

### *Nitrogen Fertilizers*

Ammonium nitrate, monoammonium phosphate and ammonium sulphate are similar in toxicity. They are all much safer than anhydrous ammonia, aqua ammonia or urea. Diammonium phosphate is more toxic than monoammonium phosphate but less toxic than urea. Take more care, particularly with sensitive seeds and on coarse-textured soil (sand and sandy loam), than is required with ammonium nitrate or monoammonium phosphate.

Because anhydrous ammonia and aqua ammonia are extremely toxic fertilizers, they should not be placed near seeds. It is preferable to make preplant applications crossways to the direction in which the crop will be planted.

Urea is toxic when banded with or near the seed but is safe when broadcast at rates normally used. Fertilizers containing more than half as much nitrogen as phosphate frequently contain urea.

### *Phosphate Fertilizers*

Phosphate fertilizers are usually low in toxicity, because a large portion of the phosphate is precipitated in the soil before it can reach the plant roots. The concentration of readily available phosphorus in soil solution at any one

**Table 2–16.**
**Soil Conductivity Reading Interpretation**

| Conductivity "Salt" Reading millisiemens/cm | Rating | Plant Response |
|---|---|---|
| 0–0.25 | L | Suitable for most plants if recommended amounts of fertilizer are used. |
| 0.26–0.45 | M | Suitable for most plants if recommended amounts of fertilizer are used. |
| 0.46–0.70 | H | May reduce emergence and cause slight-to-severe damage to salt-sensitive plants. |
| 0.71–1.00 | E | May prevent emergence and cause slight-to-severe damage to most plants. |
| Greater than 1.0 | E | Expected to cause severe damage to most plants. |

time is very low. No limit is normally set for the safe rate at which phosphates may be applied with, or near, the seed of field-grown crops.

Diammonium phosphate is more toxic than other phosphate fertilizers. (See the section *Nitrogen Fertilizers*, on page 21.)

### *Potash Fertilizers*

Muriate of potash (KCl) is the most common source of potassium in fertilizers and is less toxic per unit of plant nutrients than most nitrogen fertilizers. Sulphate of potash ($K_2SO_4$) is less toxic than muriate of potash. Sulphate of potash-magnesia has approximately the same toxicity per unit of potassium as muriate of potash. Potassium nitrate is one of the safer sources of potassium.

### *Fertilizers Containing Micronutrients*

Fertilizers containing micronutrients (boron, copper, iron, manganese or zinc) are more toxic than the same grades without micronutrients, and maximum safe rates should be reduced. Boron is particularly toxic and should not be banded.

### *Foliar Fertilizers*

Micronutrients can be supplied to the crop through foliar fertilization, particularly in instances where a deficiency is due to a tie-up of these nutrients in the soil. Quantities of nutrient that can be applied this way are limited because of the danger of burning the leaves. If applying more than one micronutrient through foliar application, this concern of leaf damage becomes greater. Check pesticide labels before mixing foliar nutrients with any pesticide spray.

## Guidelines for Safe Rates of Nutrients Applied at Seeding

Fertilizer toxicity varies widely, depending on the amount of soil moisture. To ensure completely safe rates of banded fertilizer for all seeding conditions would require extremely low rates of application. The maximum safe rates suggested in Chapter 6 of this publication will probably reduce or delay germination, or retard growth in up to 10% of the cases where they are used.

In most cases, it is advisable to use lower rates of fertilizer at seeding. If fertilizer requirements are high, it may be better to broadcast most of the fertilizer required and to band only a small portion at seeding. Fertilizers containing the micronutrients boron, copper, iron, manganese and zinc are more toxic, and the safe rates recommended at seeding will be lower than normally recommended.

### Fertilizer Placement

Phosphorus is very important for early growth. It does not move readily in the soil and is more available if placed near the seed. For transplant crops, the use of high-phosphorus starter solution is a profitable practice, especially under cool soil conditions.

Nitrogen fertilizers readily dissolve in the soil water and move easily through the soil to the plant roots. From a crop production standpoint, placement of nitrogen is less important than for phosphorus. Part of the nitrogen requirement is usually broadcast, injected or worked into the soil before planting. When it is applied in this manner, it will often encourage the breakdown of the cover crop.

Too much potassium applied in a band at planting or in the transplant water can injure young seedlings and reduce crop yield and quality. The danger of fertilizer injury is greater on sands and sandy loams than on silt loam and clay loam soils. On the coarse-textured sand and sandy loams, part of the potassium fertilizer requirements should be broadcast and worked into the soil before planting.

### *Side Dressing*

In some instances, a good portion of the nitrogen is not applied until side-dressing. This practice times the application of the nitrogen to coincide with the crop's rapid growth phase. It also helps to minimize leaching and prevent plants from too much vegetative growth. The timing and amount of nitrogen side-dressing must be judged from the appearance of the plants. On coarse, sandy soil, it may be advisable to add potash as well as nitrogen.

### Fertigation

Many fertilizers, particularly nitrogen, may be applied through the irrigation system during the growing season. For more information, see the section *Irrigation*, on page 35, for more information.

# 3. Soil Management

Most of the prime vegetable-growing soils are light in texture. Vegetable production tends to be a very intensive process, usually involving a lot of tillage. Maintaining soil organic matter levels is a challenge and an ongoing process. Soil organic matter helps maintain soil structure, enhances soil moisture-holding capacity, increases the soil's ability to hold nutrients and improves drainage. Maintaining adequate soil organic matter levels can help maintain crop yields, particularly under adverse conditions.

## Soil Quality

Soil quality is the measure of a soil's health and its ability to resist erosion, compaction and other stresses, while maintaining economic productivity. Many factors are assessed to determine a soil's health. A healthy soil will:

- have good soil structure, resist crusting and have minimal compaction
- have an abundance of earthworms
- smell good
- readily decompose residue
- have good drainage, water movement and water-holding capacity
- encourage seedling emergence and root growth
- produce uniform crop growth and colour
- have nutrient levels, pH and organic matter in the optimal range
- have suffered little wind, water or tillage erosion, and be resistant to it.

Assessing the soil quality for each field and taking steps to maintain or improve it will ensure long-term productivity. Maintaining soil quality is a continuous process. Some measures are easy and relatively inexpensive to implement, while others require more effort and commitment to put in place. Table 3–1, *Maintaining or Improving Soil Quality*, on page 24, displays a variety of measures that can be used to help maintain or improve various aspects of soil quality.

**For further information on soil management, see the OMAF/Agriculture and Agri-Food Canada booklet *Best Management Practices: Soil Management*, Order No. BMP06.**

## Subsidence of Peat and Muck Soils

Cultivated peat and muck soils decompose or subside (oxidize) gradually at rates of 1–3 cm/yr. Maintaining a high water table and a low pH reduces the rate of subsidence to less than 0.05 cm/yr. A very wet (or very acidic) soil does not give maximum yields and is likely to be flooded when rainfall is intense. Wet spots may also be difficult to work and may result in uneven crop growth.

Research has shown that copper (Cu) applied as fertilizer has the residual effect of slowing down degradation, and thus subsidence, by about 50%. Apply 14 kg of Cu/ha annually to peats and mucks in the first 3 years of cultivation and up to 5 kg of Cu/ha every second year thereafter, particularly when onions, carrots or lettuce are grown on the soils.

## Tillage Systems

The traditional role for tillage systems has been to provide weed control and prepare a seedbed that will give good crop stands and high yields. More recently, tillage and cropping systems have been changed to accomplish the same goals while reducing soil erosion through less intensive or no cultivation. Other factors favouring reduced tillage are high fuel costs and shortage of labour.

Base any decisions to switch to a different tillage system on the system's compatibility with the farm's soil types, slopes, drainage, moisture regime and temperature. The tillage system's effect on erosion control, timeliness and the potential for controlling weeds, insects and diseases are also important considerations. No one tillage system is best for Ontario conditions because there is so much variability in soils, crops and climate. In fact, the tillage system may rotate with the crop, allowing for the use of the most appropriate tillage for each crop.

### Conventional Tillage

Conventional tillage is any system that attempts to bury most of the previous crop residue, leaving less than 30% of the soil surface covered with residue after planting. Usually the moldboard plow is used in conjunction with a variety of other tillage implements.

The principal advantages of the moldboard system are that machinery is familiar and widely available and the system is adaptable to a wide range of soil conditions. Moldboard

### Table 3–1.
### Maintaining or Improving Soil Quality

| Measure | Comments |
|---|---|
| **Easy/less expensive** | |
| Use of cover crops | Use cover crops with fibrous root systems to improve soil structure, particularly at the soil surface. Use cover crops with tap roots to penetrate dense soil layers and provide protection from erosion. |
| Soil testing and accurate application of fertilizer and lime | Adequate ph and fertility will improve crop growth. |
| Reducing tillage and using residue management | Using fewer tillage passes to prepare the seedbed will:<br>• leave more residue on the surface to protect against erosion<br>• reduce soil organic matter loss<br>• leave soil aggregates intact to reduce crusting potential |
| Adding organic matter in the form of manure | Regularly adding organic materials to the soil will help increase organic matter levels in the soil, improve soil structure, increase the water-holding capacity and make the soil less prone to erosion. |
| Erosion control measures | Simple measures such as buffer strips, drop structures (rock chutes or drop pipes), tile outlet protection and strip cropping greatly reduce soil erosion. More expensive structures such as water and sediment control basins help protect fields from major soil loss. |
| **Significant management changes or investment required** | |
| Minimum tillage | Switching to minimum or no-till systems will leave more residue on the surface and help protect the soil. It will also improve soil structure. It requires investment, equipment and management changes. |
| Crop rotation including a mix of cereal, legume or grass crops | Rotating vegetable crops over a period of 3–4 years with cereal, legume or grass crops will improve soil structure, improve the water-holding capacity and make the soil less prone to erosion. |
| Planting windbreaks | Windbreaks can begin to protect soil in a few short years, and the benefits can last a lifetime. |
| Planting windstrips | Established each year, wind strips can be adapted to many different crops. Similar to windbreaks, windstrips protect the soil and prevent sandblasting and desiccation of the crop and may provide microclimate benefits. |
| Improving drainage | Tile drainage will remove excess water, allowing for more timely field operations, reduced compaction potential and improved crop growth. |

plowing increases soil porosity, allowing for good air exchange, root proliferation and water infiltration, especially when rainfall is above average. However, the increased porosity can be lost with excessive secondary tillage or in soils with poor structural stability. Many livestock producers view the moldboard plow as the most effective way of incorporating manure and breaking up sod fields.

The main weaknesses of the moldboard system include the high costs of equipment, fuel and labour associated with seedbed preparation. With little or no residue cover, there is a high risk for soil erosion by wind and water.

## Conservation Tillage

Conservation tillage systems are designed to leave more previous crop residue on the soil surface giving more protection against erosion than conventional tillage. The chisel plow has been the most widely adopted conservation tillage tool in Ontario. Tandem and offset discs are also being used extensively in some areas of the province.

Conservation tillage systems are well adapted to lighter-textured soils. These systems often require little or no modifications to conventional planting equipment.

Chisel plowing with twisted shovel teeth will often make the soil quite ridged in the spring. This can lead to extra costs in secondary tillage (more passes), uneven seed beds and occasionally excessive soil drying. Many of these problems can be overcome by:

- using sweep teeth on all or part of the chisel plow
- adding a levelling bar or harrows to the rear of the chisel plow
- practising timely secondary tillage in the spring.

## No-Till Systems

No-till systems provide the greatest opportunity to leave protective crop residues on the soil surface. They also have the greatest potential for reducing tillage costs. One drawback of this system is the need to control weeds in nearly all cases with a preplant "burndown" herbicide application.

Numerous options exist both in the original design and in the modifications available for row crop planters or seed drills to be considered capable of "no-till." Increasingly, there are more modifications available for vegetable transplanters to assist in planting through crop residues.

No-till is a technique that can be used relatively easily with some vegetable crops. The maintenance of surface crop or cover crop residues offers several benefits, including:

- the potential for weed suppression

- interference with the movement of some pests, e.g., Colorado potato beetle
- reduction of sand blasting and wind dessication
- reduction of soil water losses.

However, concerns with pests, precision seeding and crop debris during machine harvest remain a challenge for many vegetable crops.

**For further information on tillage systems, see the OMAF/Agriculture and Agri-Food Canada booklets, *Best Management Practices: Field Crop Production*, Order No. BMP02, *Best Management Practices: No-Till: Making It Work*, Order No. BMP11, and *Best Management Practices: Soil Management*, Order No. BMP06.**

## Cover Crops

Cover crops play a major role in Ontario by providing ground cover to reduce erosion and by adding organic matter to improve the soil. Following is information on some of the more commonly used cover crops. See also Table 3–2, *Characteristics of Cover Crops Grown in Ontario*, below.

### Grasses

Grasses have fine, fibrous root systems that are well suited to holding soil in place and improving soil structure. Grass species suitable for cover crops are fast growing and relatively easy to kill (either chemically, mechanically or by winter weather). Grasses do not fix any nitrogen out of the atmosphere, but they can scavenge large quantities from the soil.

#### *Ryegrass (Annual, Italian or Perennial)*

Ryegrass is direct seeded in the spring or from August to mid-September. It can also be seeded with a nurse crop in the spring or broadcast into corn in late June–early July with some success. Annual ryegrass gives the most top growth in the seeding year. It often heads 6–8 weeks after seeding. Italian ryegrass (a biennial) does not head in the seeding year, so top growth is considerably less. However, it has the largest, densest root system of the three types. Annual and Italian ryegrasses usually suffer considerable winterkill, but part of the stand may survive. Perennial ryegrass normally survives the winter.

*Cautions:* Establishment and growth of ryegrasses can be poor during very hot, dry weather. It can be difficult to kill overwintering ryegrass with merely cultivation or discing. The nitrogen tied up in ryegrass releases more slowly than from many other cover crops. As a result, corn after ryegrass often requires an extra 20–30 kg/ha of nitrogen.

**Table 3–2.**
**Characteristics of Cover Crops Grown in Ontario**

| Species | Normal Seeding Time | Seeding Rate kg/ha | Nitrogen[1] Scavenging Potential | Overwintering Characteristics | Potential Weed Problem From Volunteer Seed | Nematode Rating[2] | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lesion | Root-knot |
| **Grasses** | | | | | | | |
| Ryegrass | April to May or Aug to early Sept | 13–17 | moderate | annual, Italian: partial survival. perennial overwinters. | no | | |
| Spring cereals | Mid-Aug to Sept | 100–125 | moderate | killed by heavy frost | no | + | |
| Sorghum sudan | June to Aug | 50 | moderate-high | killed by frost | no | NH[2] | |
| Pearl millet | June to Aug | 9–10 | moderate-high | killed by frost | no | NH[2] | NH[2] |
| Winter wheat | Sept to Oct | 100–125 | moderate-high | overwinters well | no | + | NH |
| Winter rye | Sept to Oct | 100–125 | high | overwinters very well | no | + [3] | NH |
| **Legumes[4]** | | | | | | | |
| Hairy vetch | Aug | 20–30 | low (fixes N) | overwinters | no | ++ | + |
| Red clover | Mar to April | 8–10 | low (fixes N) | overwinters | no | ++ | +++ |
| Sweet clover | Mar to April | 8–10 | low (fixes N) | overwinters | no | | |
| **Non-Legume Broadleaves** | | | | | | | |
| Buckwheat | June to Aug | 50–60 | moderate | killed by first frost | yes | +++ | NH |
| Oilseed radish[5] | Mid-Aug to early-Sept | 10–14 | high | killed by heavy frost | yes | NH[2] | NH[2] |

Nematode Rating Codes: = poor or non-host + = ability to host NH = non-hosts

[1] The potential for nitrogen uptake is influenced by seeding date, stand establishment and growing conditions.
[2] Varietal differences in cover crop species may affect nematode reaction.
[3] Rye whole season rating would be higher (+++).
[4] Some diseases caused by *Pythium* and *Phytophthora* can be more severe after legume cover cropping.
[5] Oilseed radish residues can be toxic or allelopathic to subsequent crops if the following crop is planted too closely after green manuring. Allow the green manure residues to break down or dessicate before planting the next crop.

### *Spring Cereals*

Spring cereal cover crops are usually seeded for plowdown. Stands seeded from mid-August to mid-September will have 20–40 cm of growth by freeze-up. The stand is generally killed by late, hard frosts.

Volunteer spring cereals are sometimes left to grow until freeze-up as a cover crop. Stands may not be very uniform.

On erosion-prone knolls, spring cereals often have little growth and have been observed to "blow off" by spring and may open the whole field to more erosion.

*Cautions:* Early seeding may result in considerable growth by freeze-up. If left unplowed in the fall, the mat of dead residue will slow soil drying and warming in the spring, which can cause problems in early-seeded crops.

### *Sorghum Sudan and Forage Pearl Millet*

Sorghum sudan and forage pearl millet are warm-season grasses. They are extremely sensitive to frost. They have extensive root systems and produce a significant amount of top growth. They are both a good choice as a midsummer green manure crop to improve the soil.

Plant in mid-June, after all threat of frost is past. These crops benefit from the warm temperatures of early to mid-summer. Approximately 50 kg/ha of N helps the crop achieve maximum top growth. A preplant herbicide treatment is recommended for crop establishment.

Planting certain cultivars of sorghum sudan and forage pearl millet in rotation with high valued horticultural crops can reduce plant parasitic nematode soil populations below economic thresholds. More than 1 year of a nematode-suppressing variety may be required to effectively reduce nematode levels. Sorghum sudan and pearl millet do not have to be incorporated green for nematode suppression. Canadian Forage Pearl Millet 101 reduces nematode populations by inhibiting the ability of nematodes to reproduce in its root system.

*Cautions:* Mow before the crop reaches 1 m in height. This encourages tillering and ensures stalks are not woody, thus allowing them to break down readily. Do not mow shorter than 15 cm to ensure regrowth.

### *Winter Rye*

Winter rye is seeded from September into mid-October, often following vegetable crops. It grows until freeze-up and then commences growth again in late March to early April (slightly earlier than winter wheat). The growth rate is very rapid during May. Kill the stand with either tillage or a herbicide in late April or early May.

Winter rye can be seeded later than any other crop and still survive over winter. For good ground cover and erosion protection, it should be seeded at least a month before freeze-up. Winter rye is one of the most consistent, flexible and economical cover crops available.

*Cautions:* Rye will grow very rapidly under warm temperatures in early spring. Monitor growth to kill it at an appropriate time. If it is allowed to grow too tall, it can deplete soil moisture, and incorporation may be difficult. Rye acts as a host for root-lesion nematode, especially when grown as a full-season crop.

### *Winter Wheat*

Seed winter wheat from late August through October. It can be seeded outside this time frame, however, weather conditions mav reduce top growth. Wheat will survive overwinter and begin growing in April. The stand can be killed through tillage or herbicide application. Compared to rye, the plant shuts down earlier in the fall and begins to grow later in the spring.

*Cautions:* Winter wheat does not generally provide the same amount of green material to return to the soil or the level of weed competition that rye provides.

## Legumes

Legume cover crops can fix nitrogen from the air, supplying nitrogen to the succeeding crop as well as protecting the soil from erosion and adding organic matter. The amount of nitrogen fixed varies between species. Generally, more top growth equals more nitrogen fixed. Some legume species have aggressive tap roots that can break up subsoil compaction, but this requires more than one year's growth to happen.

Nitrogen release from legumes can be inconsistent. This must be accounted for when calculating your fertilizer needs. Excess nitrogen release late in the season could lead to excess vegetative growth in fruiting vegetables, such as tomatoes, peppers and melons.

### *Hairy Vetch*

To provide good ground cover over winter, hairy vetch must be seeded by mid-August. It grows slowly until freeze-up, establishing a very vigorous, fibrous root with moderate top growth. Hairy vetch may also be drilled into winter wheat when the wheat is about 20 cm tall. Seeding at this stage prevents the hairy vetch from causing a problem with wheat harvest but results in much more vetch growth by freeze-up compared to August seedings.

Hairy vetch vines resume growth early in the spring (similar to the time for winter wheat) and may reach 150 cm in length if left to maturity. Plowdown stands are usually killed in the spring by tillage or herbicide application. Vetch's fibrous root system improves soil structure. It also adds large amounts of fresh organic matter to the soil.

*Cautions:* Competition from volunteer cereals can lead to poor stands of hairy vetch. On droughty soils, hairy vetch left alive until early May may deplete soil moisture. Roundup is not effective in killing hairy vetch; use 2,4-D, MCPA, Banvel or their mixtures. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

### *Red Clover*

Red clover is commonly broadcast into winter wheat in March or early April or seeded with spring cereals. Early seeding gives best stands. Double-cut red clover produces considerably more top growth than single cut (60 cm vs. 25 cm, respectively). For plowdown, common seed produces equal results to pedigreed seed, although it may contain more weed seeds.

Major growth takes place from grain harvest until a heavy frost. Red clover can be killed in the fall or the spring by tillage or herbicide application. Unless herbicides are also applied, chisel plowing will not kill the stand completely.

Red clover plowdown improves soil structure and adds large amounts of fresh organic matter. Nitrogen is fixed and released slowly to the following crop. It gives excellent erosion protection when left unplowed until spring or killed in the fall with a herbicide.

*Cautions:* Roundup alone is often not effective in killing red clover; consider 2,4-D, MCPA, Banvel or mixtures. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

### *Sweetclover*

Sweetclover is most commonly seeded into winter wheat in March or early April or seeded with spring cereals. Either yellow- or white-blossom type may be used. White-blossom type produces somewhat taller top growth.

Major growth takes place after the grain is harvested until heavy frosts. Top growth will usually be 30–40 cm tall, but not dense. A strong taproot is produced, often 30 cm long and 1 cm across at the crown. If allowed to grow the following spring, sweetclover will flower in July at a height of about 180 cm, set seed and die. Plowdown stands may be killed in the fall or the following spring by tillage or with herbicides.

*Cautions:* Sweetclover is very sensitive to many herbicides and will not tolerate any phenoxy herbicides, including 2,4-D.

## Non-Legume Broadleaves

These broadleaf crops cannot fix nitrogen out of the air but they may absorb large quantities from the soil. Neither of these crops are winter-hardy, so additional control measures are not normally required. Do not allow these crops to go to seed, as the volunteer seed can become a significant weed problem.

### *Buckwheat*

As a cover crop, buckwheat is most commonly seeded in late June to early August. It grows very rapidly, reaching flower stage and a height of 45–75 cm in about 6 weeks. It has a relatively small fibrous root system and is completely killed by the first frost.

Buckwheat provides rapid soil cover and gives good erosion protection during the growing season. It smothers annual weeds and suppresses perennial ones. Moderate amounts of fresh organic matter are returned to the soil. Buckwheat does not fix nitrogen.

*Cautions:* Late summer seedings may be killed by an early frost before providing significant growth.

### *Oilseed Radish*

Oilseed radish is commonly seeded in August or very early September. It is unaffected by early frosts. It can grow to a height of 50–90 cm and bloom in October. The plant has a thick but short taproot, varying between carrot and turnip shaped. It is killed by severe frosts in late November or December.

Oilseed radish gives a reasonably rapid soil cover and excellent erosion protection over winter and returns moderate amounts of organic matter to the soil. For good growth, this crop must have a large amount of available nitrogen, either from a recent manure application or left-over from a previous crop.

Some oilseed radish (and certain mustard) cultivars can help to reduce plant parasitic nematode populations in the soil. The nematode-suppressing cultivars must be incorporated into the soil as a "green manure" crop. As the green residue breaks down, it releases a nematode-killing compound (isothiocyanate) into the soil.

*Cautions:* Growth will be poor if soil nitrogen levels are low or if compaction is severe. Scattered volunteer plants usually appear in most crops planted after oilseed radish. More than

1 year of a nematode-suppressing cover crop may be required to successfully reduce nematode population levels.

**For more detailed information on cover crop use and management, see the OMAF Web site at www.gov.on.ca/OMAF/english/crops/facts/cover_crops01/covercrops.htm.**

### Tillage Systems After Cover Crops

In conservation and no-till cropping systems, cover crops can greatly increase the surface residue cover, adding to the potential benefits of the system.

Management factors to consider when reduced tillage follows cover crops are:

- Some regrowth of winter annual, biennial or perennial cover crops will occur in the following crop year. Usually this is easily controlled with normal herbicide treatments in the following crop. A controlled amount of regrowth (for example, windstrips) can provide some spring wind protection.
- The first conservation tillage operation with overwintering cover crops should occur at least 2 weeks prior to planting to allow the breakdown of the residue to start.
- Seedbed preparation may be difficult if persistent cover crops are not tilled until spring or if they are allowed to grow too large.
- Cover crops that do not survive over winter may be an option, especially on more poorly drained soils or for crops that are planted very early in the spring.
- Burndown herbicides should be considered before conservation tillage of overwintering cover crops such as rye. Careful timing, rate and application of herbicides can help keep enough residue on the surface to prevent wind damage to tender crops while allowing crop establishment.

## Water Quality

Water is a valuable resource. A clean and abundant supply of water is critical to the success of the farm business and the health of your family. Others, including fish and wildlife, share our water resources. Growers have a right to expect an ample supply of clean water, and it is their responsibility to ensure that the water leaving the farm is abundant and clean for the next user.

Farm operations impact water quality in many ways. Soil erosion, manures, septic system effluent, milkhouse wastes, fertilizers, pesticides and fuel can affect surface and/or groundwater quality.

The greatest water quality challenges affecting farmers involve bacteria (mostly from manures), nitrates, phosphorus and sediment. Problems can be minimized using the following practices.

### Bacterial Contamination

- Contain run-off from manure storages, livestock yards, silos and cull piles.
- Avoid spreading manure on frozen or snow-covered ground.
- Make sure wells are properly maintained and protected from surface contamination.
- Ensure that the domestic septic system is working properly and is not discharging into a drainage system.

### Soil Erosion

- Adopt the conservation tillage practices outlined earlier in this section.
- Install erosion-control structures.
- Use cover crops and wind-abatement crops.

### Nitrate Contamination

- Complete and follow a nutrient management plan for the farm.
- Avoid spreading excessive amounts of manure or fertilizers.
- Use cover crops to capture residual nitrogen.
- Where a lot of manure and forages are used, use the nitrate soil test to determine nitrogen requirements.
- Reduce nitrogen fertilizer when the previous crop was a legume or when manure was applied.

**The following booklets from OMAF, Agriculture & Agri-Food Canada and the Ontario Federation of Agriculture contain more information on water quality problems and solutions, soil conservation measures and nutrient and manure use:**

- ***Best Management Practices: Water Management***
- ***Best Management Practices: Soil Management***
- ***Best Management Practices: Horticulture Crops***
- ***Best Management Practices: Field Crop Production***
- ***Best Management Practices: Nutrient Management***
- ***Best Management Practices: Pesticide Storage, Handling & Application***
- ***Best Management Practices: Water Wells***

**To order, contact the Ontario Federation of Agriculture, Attn: Manager, BMP; 40 Eglinton Ave. E., 5th floor, Toronto, ON, M4P 3B1. Phone: (416) 485-3333; fax: (416) 485-9027; e-mail: ofarsch@flexnet.com.**

# 4. Vegetable Production Practices

## Climate

Most vegetable production is concentrated in Southern Ontario. There are differences in climate even in this small area, particularly in the length of the growing season and in average temperatures. Vegetable crop development is often referred to by the number of days to maturity. This measure indicates the number of days from planting to harvest maturity under average growing conditions.

### Climate Zones and Planting Dates

As shown in Figure 4–1, *Climate Zone Map of Ontario*, on page 30, Zone A, in the Leamington-Harrow-Amherstburg area bordering on Lake Erie, has the longest growing season. The growing seasons of the other zones are progressively shorter. The zone lines are approximate and do not represent sharp changes in climate. The gradation of temperature and growing season from one zone to another is gradual.

Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 30, defines each lettered zone on the map. It gives the average dates of first and last frost (0°C) in each zone based on climate data from 1961 to 1990.

The dates listed in the table indicate that one year in two (50% of the time) there will be frost in these locations by that date. There is a 25% risk of a frost occurring 7 days after the listed last spring frost date. The risk decreases to 10% 14 days after the listed date. Conversely, there is a similar risk factor associated with frost occurring before the first fall frost dates.

Note that the frost dates in Table 4–1, on page 30, refer to the occurrences of 0°C at a standard height of 1.5 m, at which time tender crops will often be damaged. Frost-hardier crops are not usually damaged until temperatures at this height drop below –2°C. The date of occurrence of –2°C is usually about 2 weeks earlier in the spring or later in the fall than the date of 0°C.

Growing conditions are also influenced by local variations due to topography, altitude, natural air drainage and nearness to water. Cold air tends to flow into low-lying areas. Plants at the bottom of a slope are often the first to suffer frost injury. Local variations must be considered in deciding the location and time of planting.

Table 4–2, *First Field Seeding or Planting Dates for Commercial Production*, on page 31, gives approximate first seeding or planting dates for common vegetable crops. Dates are given for Zones A, C and E. Planting dates for the other zones fall between these dates. These dates are only a guide. Take seasonable variations into consideration.

For many crops, the soil temperature is very important in determining the rate of early growth. Delay planting if the soil is still cool, even if the air temperature is high.

### Growing Degree Days and Crop Heat Units

Growing degree days (GDD) are used to estimate the growth and development of plants and insects during the growing season. They tend to be more accurate than "days to maturity."

As an organism develops over a growing season, the development is closely related to the daily accumulation of heat. A certain amount of heat is required to provide enough energy for the organism to move to the next development stage, for example, emergence of a new trifoliate on a snap bean plant or the first flight of European corn borer adult moths. The amount of heat required to move to the next development stage remains constant from year to year. But, depending on weather conditions, the amount of actual time can vary between years.

Each organism has a minimum base temperature or threshold at which development does not occur. These base temperatures are different for each organism.

To calculate GDD, first determine the mean temperature for the day. This is usually done by taking the maximum and minimum temperatures for the day, adding them together and dividing by two. The base temperature is then subtracted from the mean temperature to give a daily GDD. If the daily GDD calculates to a neg-

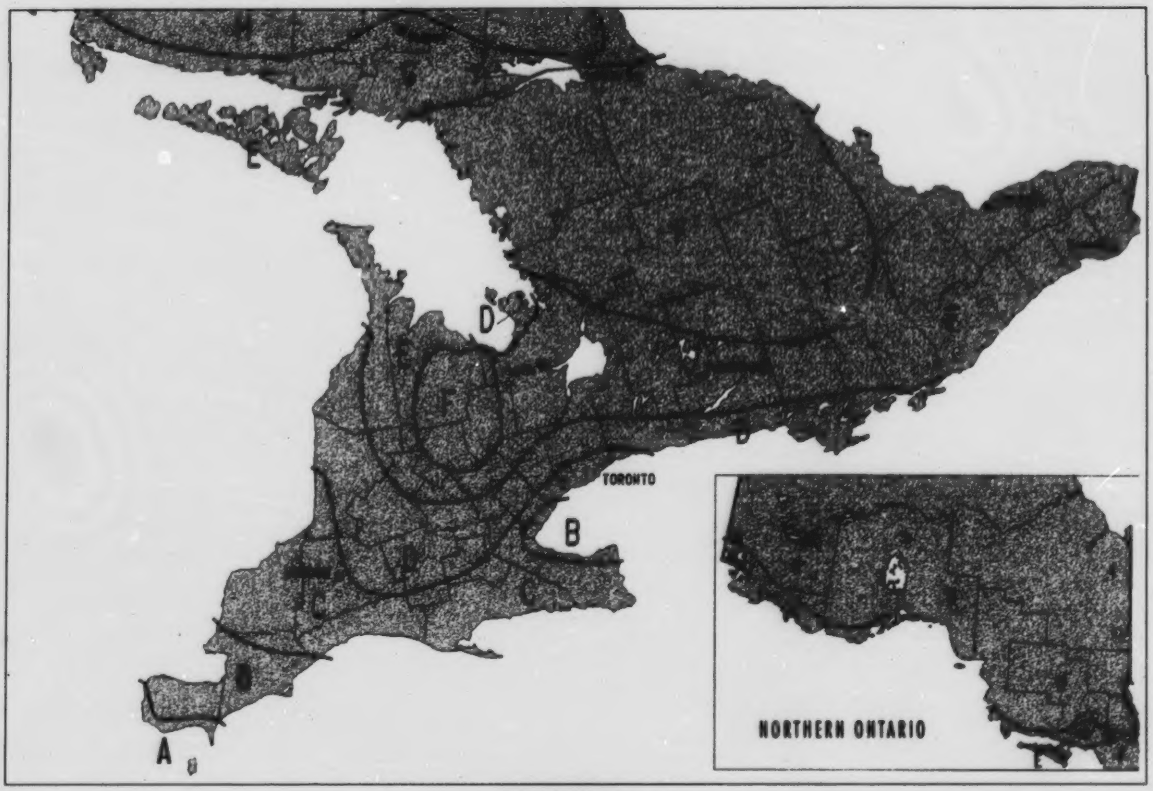


**FIGURE 4–1.**
**Climate Zone Map of Ontario**

ative number it is made equal to zero. Each daily GDD is then added up (accumulated) over the growing season.

$$\frac{\text{Daily Maximum Temperature} + \text{Daily Minimum Temperature}}{2} - \text{Base} = \text{Growing Degree Days}$$

There are GDD models developed for some vegetable crops. There are four factors to consider when comparing GDD accumulations from various sources or regions.

- Are the base temperatures used in the equations the same? Different organisms have different base temperatures used to calculate growing degree days. 150 GDDs at base 10 does not equal 150 GDDs at base 0.
- Are the start dates for the accumulations the same? Generally, GDD accumulations start on April 1 each year but some insect GDD models start at the emergence of a specific life stage. This is referred to as a biofix.
- Are the equations used to calculate the daily GDDs the same? Many modifications to the simple GDD calculation have been developed over the years and may be referred to generally as degree days.
- Are the temperatures used in degrees Celsius or Fahrenheit? GDD accumulations will vary significantly, depending whether they are being tracked in Celsius or Fahrenheit. GDD models have been designed specifically for use in Celsius or in Fahrenheit and cannot be interchanged without making conversions.

It is important when looking at these crop development models that the base temperature is known. Confusion

**Table 4–1.**
**Average Frost-Free Period**
**in Climatic Zones of Ontario**

| Zone | Frost-free Period (Average in Days) | Average Date of Last Spring Frost | Average Date of First Fall Frost |
|---|---|---|---|
| A | 180 | April 25 | October 25 |
| B | 165–180 | May 5 | October 15 |
| C | 145–165 | May 10 | October 10 |
| D | 130–145 | May 18 | October 2 |
| E | 120–135 | May 22 | September 28 |
| F | 105–120 | May 31 | September 20 |
| G | 100–120 | May 25 | September 15 |
| H | 100 or less | After May 25 | Before Sept. 15 |

### Table 4–2.
### First Field Seeding or Planting Dates for Commercial Production

| Crops | Zone A | Zone C | Zone E |
|---|---|---|---|
| **Frost Hardy** | | | |
| Asparagus, broccoli, Brussels sprouts, cabbages, lettuce, onions (set, seed, Spanish), radishes, rhubarb, peas, spinach, parsnips, early potatoes | April 1–15 | April 15–25 | April 25–May10 |
| **Semi-Frost Hardy** | | | |
| Beets, carrots, cauliflower, celery, late potatoes, early sweet corn | April 15–25 | April 25–May 10 | May 5–15 |
| **Semi-Frost Tender** | | | |
| Snap beans, sweet corn, tomatoes | May 1–15 | May 15–25 | May 25–June 5 |
| **Frost Tender** | | | |
| Lima beans, cucumbers, eggplant, muskmelons, peppers, pumpkins, squash, watermelons | May 20–30 | May 25–June 5 | June 5–15 |

has been created over the years by the terminology used to describe growing degree days.

In Ontario, the terms growing degree days (GDD) and crop heat units (CHUs) are used. These terms represent two very different development models. The crop heat units calculation now used in Ontario is identical to the traditional corn heat units calculation. Its name was changed to reflect its now broader application to other crops.

Growing degree days are sometimes referred to as "degree days" or "degree days averaging method." Some jurisdictions use the term "heat units" interchangeably with degree days.

For more information on crop heat units, refer to the OMAF Factsheet, *Crop Heat Units for Corn and Other Warm-Season Crops in Ontario*, Order No. 93-119.

## Seeding Practices

### Seed

Use only high-quality seed, which is certified disease-free and treated to eliminate or protect against insects and diseases.

### Table 4–3.
### Vegetable Seed Life Expectancy

| 1 to 2 Years | 3 to 4 Years | | 5+ Years |
|---|---|---|---|
| corn | asparagus | fennel | cucumbers |
| leeks | beans | kale | endive |
| okra | beets | mustard | lettuce |
| onions | broccoli | peas | muskmelons |
| parsley | Brussels sprouts | pumpkins | radishes |
| parsnips | cabbages | rutabagas | |
| peppers | carrots | spinach | |
| rhubarb | cauliflower | squash | |
| | celery | tomatoes | |
| | Chinese cabbage | turnips | |
| | eggplant | watermelons | |

Registered seed treatments are listed in the individual crop sections in Chapter 6, *Crop Management Recommendations.*

There is no advantage to compromising on seed cost. This is a small part of the total cost of growing the crop. Saving your own seed is not recommended because of the potential for disease contamination and because hybrid cultivars do not grow true to type. For certain popular varieties, seed should be ordered as much as 1 year in advance to ensure availability.

### *Pelletized and Primed Seed*

Pelletized seed has been coated to make it larger or more uniform. Onion, carrot and lettuce seed tends to be irregularly shaped or small. Pelletized seed makes the mechanical planting of these crops much easier.

Primed seed has been partially hydrated, then dried down. This treatment results in earlier germination and better uniformity, especially for hard to germinate seeds such as triploid watermelon varieties.

### *Germination, Vigour and Seed Storage*

Germination and vigour of all seed declines over time. Storage temperatures of 5°C–10°C (41°F–50°F) and 40%–50% relative humidity are ideal. Excessively low humidity may result in poor germination rates. High humidity will increase the likelihood of fungal contamination.

Seed should be stored in waterproof, vapourproof containers. Life expectancy, even under good storage conditions, varies between different types of vegetables. See Table 4–3, *Vegetable Seed Life Expectancy*, above.

Keep in mind that seed vigour declines more rapidly than germination. If seed is past its prime, it may still germinate, but the seedlings will be weaker and more prone to disease.

### Table 4–4.
### Number of Plants per Hectare at Various Planting Distances

| Row Spacing (cm) | Distance Within the Row (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10 | 15 | 30 | 45 | 60 | 75 | 90 |
| 30 | 333,330 | 222,220 | 111,110 | 74,070 | 55,560 | 44,440 | 37,040 |
| 45 | 222,220 | 148,150 | 74,070 | 49,380 | 37,040 | 26,630 | 24,690 |
| 60 | 166,670 | 111,110 | 55,560 | 37,040 | 27,780 | 22,220 | 18,520 |
| 75 | 133,330 | 88,890 | 44,440 | 29,630 | 22,220 | 17,780 | 14,810 |
| 90 | 111,110 | 74,070 | 37,040 | 24,690 | 18,520 | 16,460 | 12,350 |
| 110 | 90,910 | 60,610 | 30,300 | 20,200 | 15,150 | 12,120 | 10,100 |
| 120 | 83,330 | 55,560 | 27,780 | 18,520 | 13,890 | 11,110 | 9,260 |

## Plant Populations

Each crop should be spaced according to its optimum needs. The distance between rows will be determined by the method used to harvest the crop. Specific spacing recommendations can be found in the individual commodity sections in Chapter 6.

For average plant populations at various row spacings, see Table 4–4, *Number of Plants per Hectare at Various Planting Distances*, above.

Table 4–5, *Row Length per Acre or per Hectare at Various Row Spacings*, below, shows the row length per acre (or hectare) at various row spacings. Table 4–6, *Approximate Planting Depth and Seeds per Gram*, right, outlines the approximate planting depth and number seeds per gram for each vegetable crop.

### Table 4–5.
### Row Length per Acre or per Hectare at Various Row Spacings

| Distance Between Rows | | Length of Row | |
|---|---|---|---|
| Imperial | Metric | Feet of Row/ Acre | Metres of Row/ Hectare |
| 12 in. | 30.48 cm | 43,560 | 32,800 |
| 18 in. | 45.72 cm | 29,040 | 21,872 |
| 20 in. | 50.8 cm | 26,136 | 19,685 |
| 24 in. | 61.96 cm | 21,780 | 16,139 |
| 30 in. | 76.2 cm | 17,424 | 13,100 |
| 36 in. | 91.44 cm | 14,520 | 10,936 |
| 40 in. | 1.016 m | 13,068 | 9,842 |
| 42 in. | 1.067 m | 12,445 | 9,372 |
| 48 in. | 1.219 m | 10,890 | 8,203 |
| 60 in. | 1.524 m | 8,712 | 6,561 |
| 72 in. | 1.829 m | 7,260 | 5,467 |
| 84 in. | 2.134 m | 6,223 | 4,686 |
| 96 in. | 2.438 m | 5,445 | 4,102 |

### Table 4–6.
### Approximate Planting Depth and Seeds per Gram

| Crop | Seeds per Gram | Seed Planting Depth (mm) |
|---|---|---|
| Asparagus | 50 | 25 |
| Beans, snap | 2–3 | 40 |
| Beans, lima | 1–3 | 40 |
| Beets, Swiss chard | 50 | 15 |
| Broccoli | 320 | 5 |
| Brussels sprouts | 280 | 5 |
| Cabbages | 300 | 5 |
| Chinese cabbage | 250 | 5 |
| Carrots | 900 | 5 |
| Cauliflower | 350 | 5 |
| Celery, celeriac | 1,800 | 3 |
| Chicory | 600 | 5 |
| Collard | 280 | 5 |
| Corn | 4–8 | 25–40 |
| Cucumbers | 40 | 20 |
| Eggplant | 200 | 15 |
| Endive | 500 | 5 |
| Kale | 270 | 5 |
| Kohlrabi | 280 | 5 |
| Leeks | 350 | 15 |
| Lettuce | 700 | 5 |
| Melons | 40 | 25 |
| Mustard | 550 | 5 |
| Onions | 280 | 15 |
| Parsley | 550 | 5 |
| Parsnips | 200 | 15 |
| Peas | 3–6 | 25 |
| Peppers | 150 | 5 |
| Pumpkins | 4 | 25 |
| Radishes | 125 | 15 |
| Rutabagas | 280 | 5 |
| Spinach | 90 | 20 |
| Squash | 10 | 25 |
| Tomatoes | 350 | 5 |
| Watermelons | 10 | 25 |

**Table 4–7.**
**Plastic Mulch Types**

| Type | Average Soil Warming at 2" depth | Advantages | Disadvantages |
|---|---|---|---|
| Black | 2–4° C | Prevents weed seed germination. | Good soil-to-plastic contact is necessary to ensure maximum heat transfer. |
| Clear | 4–8° C | Can be used with direct-seeded crops such as sweet corn. | Weed germination under the mulch requires good pre-plant (residual) weed control. |
| Infra-red transmitting (IRT) | 6° C | Absorbs certain wavelenghts of light, preventing weed seed germination and growth. | Expensive. Tomato and pepper yields may be lower on IRT mulches than on black. |
| Photo-degradable | Same as undegradable mulch | Breaks down with exposure to sunlight, eliminating the need for retrieval and disposal at the end of the season. | Rate of breakdown can be inconsistent. Buried edges frequently do not break down, leaving plastic residue in the field. |
| Biodegradable | Same as undegradable mulch | Usually a starch-based plastic. Broken down by soil micro-organisims. | Most of these mulches are new in the marketplace, and only limited quantities are available. Ontario grower and field trial experience is limited. |

## Plasticulture

Many vegetable crops, especially heat-loving crops such as cucurbits (vine crops), peppers, tomatoes, eggplant and sweet corn, can benefit from the use of plastic mulch and row covers (plasticulture). Some of the benefits associated with plasticulture include:

- earlier harvest
- increased yield
- higher quality produce
- soil moisture retention
- reduced disease pressure due to minimal soil/plant contact
- reduced fertilizer leaching
- weed control
- increased season long nutrient availability.

While plasticulture may be used with conventional fertilization and irrigation practices, growers should consider using drip (trickle) irrigation with fertilizer injection (fertigation) to maximize yield and quality. See the sections *Irrigation*, on page 35, and *Fertigation*, on page 36, for more information.

### Plastic Mulch

Most mulches are made of polyethylene. Table 4–7, *Plastic Mulch Types*, above, describes the different types. They are available in widths of 1.2–1.5 m (4–5 ft) with thicknesses of 1–1.5 mil (millionths of an inch). Mulches are also available in smooth and embossed. Smooth plastic has better stretch during laying, allowing for a tighter fit to the bed, initially. However, embossed plastic suffers less from expansion and contraction, allowing the plastic to better conform to the soil bed throughout the growing season.

Several commercial plastic mulch layers are available. Proper set-up of the mulch layer is essential. The edges of the mulch should be well covered, and the plastic should be tight on the soil surface to permit heat transfer to the soil. Angle the discs and press wheels of the mulch layer to ensure a tight and uniform fit.

Mulch should not be laid on dry soil. If the soil is very dry, irrigate or wait for rainfall before laying. Soil moisture is required for plant growth and is important for heat retention. Lay mulch 2–3 weeks prior to planting for maximum soil heating.

### Row Covers

Row covers can be used to make some crops produce earlier by increasing the canopy air temperature and protecting young transplants from wind damage. There are two basic types.

#### *Floating*

These are made of polypropylene or various polyester-type fabrics and are laid directly over the crop. They are available in sheets up to 15 m wide to cover multiple rows of crops. Floating covers are well suited for vine crops and other low-growing plants. They are not recommended for use on upright-growing crops like tomatoes and peppers, because they can cause abrasion on the plant's shoot tips.

### *Tunnels*

These are made of white or clear polyethylene and are supported over the crop on wire hoops. The plastic usually has slits or perforations for ventilation. Commercially available layers install hoops, lay the plastic covers over the hoops and bury the edges of the row cover in one operation.

Research in Ontario has demonstrated that use of mini-tunnels can result in earlier production of peppers, cucumbers and melons. They are not recommended for use on fresh-market tomatoes, because fruit-set can be delayed in the tunnels. Evidence also exists that demonstrates such tunnels are good for early lettuce crops.

**Regardless of the type of row cover used, heat can build up inside the covers and damage crops. Temperatures should be monitored, and the covers removed or ventilated when the temperature exceeds 32°C–35°C. For crops that require bee pollination (vine crops), row covers must be removed or opened up at flowering time.**

### Plastic Disposal

Used plastic mulches are difficult to recycle due to the amount of dirt, plant material and water present. Limited recycling opportunities do exist in some areas. In most areas, disposal at a licensed landfill site is currently the most practical option. Burning or on-farm burial is **not** recommended.

## Spraying Vegetable Crops

### Water Volume and Pressure

Generally, most insecticides/fungicides are applied with about 135–450 L/ha (54–180 L/ac). Herbicide applications range from 55–350 L/ha (22–140 L/ac).

For fungicides and insecticides, pressures of between 550–1,000 kPa and hollow cone-type nozzles are commonly used. For herbicide applications, spray pressures range from 130–300 kPa for standard flat fan orifice tips. To reduce the chance of drift, manufacturers offer drift-reducing tips that deliver the same amount of liquid but produce a coarser spray.

### Nozzle Selection

**Flat fan nozzles** provide uniform distribution on an even surface. They are best used with boom-type sprayers for herbicide applications.

**Hollow cone nozzles** are generally used to apply fungicides or insecticides. This type of nozzle generally produces a finer and more uniform spray than solid cone nozzles. Hollow cones are particularly suited to the application of wettable powders, flowables and suspensions.

**Solid cone nozzles** are used when increased penetration into the crop canopy is required.

### Air Temperature and Relative Humidity

Pesticides, especially insecticides, can cause phytotoxicity or burning of plant foliage or flowers if applied during very hot weather (above 27°C). Avoid applications between 10:00 AM and 2:00 PM, as plants will be more prone to injury. The water droplets themselves can, at times, act as tiny magnifying glasses and cause plant injury. A large portion of the spray droplets may also evaporate before they hit the target due to hot, dry air.

During conditions of high relative humidity, the drying of spray materials will be delayed. Prolonged and slow drying of pesticides can lead to phytotoxicity in some instances.

Also note that "synthetic pyrethroid"-type insecticides (Ripcord, Cymbush, Pounce, Matador, etc.) break down quickly when temperatures are above 27°C, reducing their effectiveness. If possible, apply other materials or apply these in the evening when temperatures have dropped.

### Rainfall

The decision to spray just prior to a rain or shortly after should be based on plant protection. This may be more critical when applying fungicides. Once they have dried, most fungicides can withstand about 2.5 cm of rainfall and still provide adequate protection.

Waiting for the rain to stop before the initial application may allow disease organisms to invade plant tissue unimpeded by protective sprays.

Many preemergent herbicides are best applied before a rain. Moist soils allow for better distribution within the seed zone. Postemergent applications are best applied after a rain or should at least be allowed to dry adequately prior to rainfall.

### Wind Speed & Drift

When applying fungicides and insecticides, moderate air movement helps move the product in and around the crop. Optimum air movement is 3–8 km/h. In addition, light winds will help in the drying process.

### Table 4–8.
### Classification of Vegetable Crops by Rooting Depth

| Shallow-Rooted (down to 30 cm) | Intermediate (30–60 cm depth) | Deep-Rooted (deeper than 60 cm) |
|---|---|---|
| celery | broccoli | asparagus |
| lettuce | beans, snap | parsnips |
| onions | cabbages | pumpkins |
| potatoes | carrots | sweet corn |
| radishes | cauliflower | watermelons |
|  | cucumbers | winter squash |
|  | muskmelons |  |
|  | peppers |  |
|  | tomatoes |  |
|  | zucchini |  |

To prevent unwanted drift, avoid spraying when the wind speed is more than 16 km/h. Drift is also possible at lower wind speeds. Drift potential is affected by the interaction of travel speed, wind speed and droplet size.

Some herbicides can drift for up to 6 km, and plants such as grapes, beans, peppers and tomatoes are particularly sensitive to dicamba, glyphosate and 2,4-D injury. When applying herbicides, drift can be minimized by:

- using larger droplet sizes
- not applying during very hot and dry weather (temperatures in excess of 27°C) when spray material can readily volatilize.

For more information on drift reduction, see the section *Ten Ways to Reduce Drift*, on page 6.

## Irrigation

Most vegetable crops require a uniform supply of moisture throughout the growing season. The average rainfall in Ontario is 70 mm/month during the growing season. This provides only 65% of the water needed for optimum yield.

### Crops, Soils and Water Demand

Soil types differ in their ability to retain water following rainfall or irrigation. Water that is held by the soil and can be taken up by plants is called "available soil moisture" (ASM).

Sands and coarse sandy loams retain approximately 25 mm of ASM in the crop's rooting zone. Under average conditions, a crop will use this moisture in 7 days. On these soils, a weekly irrigation of 25 mm of water would be required to maintain high yields.

### Table 4–9.
### Critical Periods for Irrigation of Several Vegetable Crops

| Critical Period | Crop |
|---|---|
| Flowering, pod setting | snap beans |
| Head formation and enlargement | broccoli |
|  | cabbages |
|  | cauliflower |
| Tasseling, pollination, ear filling | sweet corn |
| Flowering, fruit set and development | cucumbers |
|  | muskmelons |
|  | zucchini |
| Bulb formation and enlargement | onions |
| Flowering, fruit set and enlargement | eggplant |
|  | peppers |
|  | tomatoes |

Fine sandy loams and silty loams retain 40–60 mm of ASM in the rooting zone. On these soils, heavier and less frequent irrigations (40–60 mm of water every 10–14 days) are required for optimum yields. Application of more water than is required wastes water and can cause leaching of fertilizers and pesticides.

Different vegetable crops also vary in their response to irrigation. Shallow-rooted crops such as potatoes and celery require frequent, light irrigations. Deep-rooted crops can use water from a greater volume of the soil profile and do not require irrigation as frequently. Table 4–8, *Classification of Vegetable Crops by Rooting Depth*, left, shows the relative rooting depths of a number of vegetable crops.

In addition, most vegetable crops have growth stages during which drought stress can severely reduce yield and quality. Irrigation is especially important during these critical growth periods, listed in Table 4–9, *Critical Periods for Irrigation of Several Vegetable Crops*, above.

### Irrigation Systems

A number of different types of irrigation systems have been adapted for use in vegetable crops.

#### *Hand-Moved Sprinklers*

This is the least expensive overhead irrigation system. The labour cost to move the laterals through the field is relatively high. Water distribution is very uniform, although tall crops are not easily irrigated. Sprinkler irrigation may also be used for frost protection.

### Travelling-Gun Systems

These systems are relatively expensive. Labour cost is reduced compared to hand-moved sprinklers. They are well suited to irrigating large fields and tall crops. Uniformity of water distribution is greatly affected by wind conditions.

### Centre-Pivot and Lateral Systems

These are self-propelled systems located to move through and irrigate large fields from a centrally located well or pump. These systems are expensive. Labour costs through the season are low. They are adapted for use in large, relatively level fields.

**Note: You must have a Permit to Take Water issued by the Ministry of the Environment and Energy to use more than 50,000 L of water in a day from either surface or groundwater sources for irrigation.**

### Drip (Trickle) Irrigation

Drip irrigation systems consist of a series of drip lines (plastic tubing with built-in emitters) laid along the crop rows. Crop yields are comparable or slightly higher than with overhead irrigation. If fertilizer injection is combined with drip irrigation, greater yield increases are possible (see the section *Fertigation*, right.)

The cost of installing a drip system is relatively high. However, the labour cost through the season is very low. A major advantage of drip systems is that less water is required. Drip irrigation provides the crop with a uniform supply of water through the season.

A drip irrigation system consists of a filtration system, flow meter, pressure regulator, main line, header lines and lateral lines with built-in emitters (drip tubing or tape). A fertilizer injector is also required for fertigation.

Growers should consult with a specialist at an irrigation company for information on designing a drip irrigation system.

## Irrigation Scheduling

Whichever type of irrigation system is used, it is important to use some method of irrigation scheduling to avoid drought stress and provide water when it is most needed. There are two basic methods of irrigation scheduling.

### Water Budget Method

This method uses climatic data to estimate the amount of available water lost from the rooting zone through crop use and evaporation. The amount of crop water use is calculated using the percentage of crop cover and the evapotranspiration rate from climatic data. Further details of this method are provided in the OMAF Factsheet, *Irrigation Scheduling for Tomatoes — Water Budget Approach*, Order No. 90-049.

### Measuring Soil Moisture

There are several tools available for measuring soil moisture content.

**Tensiometers** measure how strongly water is being held by the soil. As the soil dries out, moisture is more strongly held to soil particles and less available to the crop. Tensiometers can be used to determine when moisture stress occurs, and thus when irrigation should be started. Sandy soils are irrigated when soil moisture tension reaches 15–20 centibars. Irrigate loamy soils at 20–25 centibars. These units require proper installation and regular maintenance. Accuracy may be reduced on soils with high clay content.

**Electrical Resistance Blocks** also measure soil water tension in centibars. Compared to tensiometers, they are easier to install. The portable meter and low cost of the units is more conducive to reading soil moisture at several different sites.

**Time Domain Reflectometry (TDR)** is the most costly tool for soil water monitoring. It is portable and quick. Some units require calibration and may be finicky to work with. Accuracy may be reduced on soils heavier than a clay-loam.

**For more irrigation information, refer to:**

- ***Irrigation Best Management Practices*, Order No. BMP08**
- **OMAF Factsheet *How to Prepare for Irrigation During Water Shortages*, Order No. 99-023.**

## Fertigation

Fertigation is a method of applying water and nutrients through a drip irrigation system. It can be used to increase the yield and quality of many vegetable crops.

A stock solution of soluble (greenhouse grade) fertilizer is dissolved in a tank and introduced through a valve into the irrigation system either by suction or pressure. The fertilizer solution should be fed through the system slowly. After the fertilizer has passed through the system, continue to irrigate to flush the system.

DO NOT mix fertilizers containing calcium, phosphates or sulphates as these can precipitate out and plug emitters.

**Table 4–10.**
**Nitrogen and Potash Injection Schedules**

| | Rate of N and $K_20$ to Inject Per Week (kg/ha) | | |
|---|---|---|---|
| **Growth Stage** | **Vine Crops**[1] | **Peppers** | **Tomatoes** |
| Transplanting to fruit set | 5 | 3–5 | 2.5 |
| Fruit sizing to harvest | 10 | 7–10 | 5 |
| Harvest | 5 | 3–5 | 2.5 |

[1] Cucumbers, melons, summer squash.

Broadcast all of the phosphate requirement and approximately 30%–50% of the nitrogen and potash requirement prior to planting. The remainder should be injected through the drip irrigation system. Use soil tests to determine phosphate and potash requirements. Table 4–10, *Nitrogen and Potash Injection Schedules*, above, outlines recommended application rates for tomatoes, peppers and vine crops.

## Food Safety

Food safety hazards include physical, chemical or biological substances that can cause produce to become an unacceptable health risk to consumers.

| | |
|---|---|
| Physical hazards: | Foreign objects (i.e., wood, plastic, glass) from the environment or equipment |
| Chemical hazards: | Pesticide or other contaminants |
| Biological hazards: | Micro-organisms such as bacteria, viruses, parasites, moulds |

Contamination of produce at the farm level can occur directly or indirectly. Produce may become directly contaminated by food safety hazards on the farm or indirectly through contaminated soil, water, etc. Growers can minimize the risk of contamination by being aware of the hazards, identifying potential sources of contamination and using best management practices. Periodically review all farm practices with food safety in mind.

Many growers already incorporate the good agricultural practices presented below. However, this is difficult to verify without documentation. Good records of on-farm food safety practices are useful in today's marketplace.

### Preventing Biological Hazards

Potential sources of contamination include:

- Untreated (raw) manure used as fertilizer
- Contaminated soil, water or feces (from rodents, domestic animals, birds, wildlife, etc.)
- Containers or equipment that have not been cleaned adequately
- Infectious workers.

### Good Agricultural Practices

Good agricultural practices can help minimize the risks from these biological hazards.

***Field History:*** Fields on which livestock have grazed or where biosolids (sludge) has been applied are more likely to have pathogenic bacteria.

***Birds:*** Discourage the roosting of birds above packing, handling and storage areas

***Manure:*** Use composted or well-aged manure to reduce microbe levels. Maximize the period between manure application and crop harvest. Incorporate manure into the soil before planting. Do not apply manure after planting where direct or indirect contact may occur with the edible crop part. Locate manure piles away from vegetable crops and packing areas to avoid contamination from wind drift or run-off.

***Water:*** Make sure water quality is appropriate for the use. Use potable water for hand washing, produce washing and hydrocooling. Consider testing irrigation water for bacterial levels. Surface water sources require more frequent testing than ground water. Consider installing drip irrigation systems, especially for produce that is eaten uncooked.

***Storage:*** Rapid cooling after harvest will help maintain quality. Keep coolers and storage areas clean (see the section *Storage Sanitation*, on page 38.)

***Worker Hygiene:*** Ensure toilets have hand-washing stations that are clean, well stocked and readily accessible. Teach workers the importance of hygiene practices.

**For more information, refer to these Web sites:**

Ontario Ministry of Agriculture and Food: www.gov.on.ca/OMAF

Canadian Water; Quality Guidelines for Agricultural Water: www.ec.gc.ca/ceqg-rcqe/English/pdf/water_summary_table-agriculture.htm

CHC guidelines: www.hortcouncil.ca/offs.htm

Canadian Food Inspection Agency: Code of Practice for Minimally Processed Ready-to-Eat Vegetables: http://inspection.gc.ca/english/plaveg/fresh/read-eat_e.shtml

## Storage

To preserve the quality of harvested vegetables and improve the marketing of crops, proper storage immediately after harvest is necessary. Rapid, uniform cooling to remove field heat followed by proper storage conditions will ensure that a quality product reaches the consumer or processor.

### Storage Tips

- Thermometers are not expensive. Have several in the storage area to help ensure the area is being uniformly cooled. Calibrate thermometers regularly to ensure that fresh produce is stored properly. Thermometers set into ice water should read 0°C.
- Change the wash water daily when washing fresh produce. This prevents the build-up of bacteria. Fresh produce infected with bacteria will break down readily in storage even under cool conditions. Use chlorine at 150–200 ppm to help prevent rot from getting started.
- The quality of the produce coming out of storage will reflect its quality going in.

### Storage Life for Fresh Vegetables

See Table 4–11, *Storage Life for Fresh Vegetables in Commercial Storage*, on page 39, for recommended storage conditions for individual crops.

### Ethylene

Ethylene is a gas that is naturally produced by most fruit and vegetables once harvested and put into storage. It acts as a growth regulator and a ripening agent. Ethephon is a synthetically produced ethylene product available commercially. It is widely used in the processing tomato industry (see the section *Chemical Fruit Ripening*, on page 148).

Ethylene gas increases the rate of ripening of mature fruits and vegetables, and shortens their shelf life. The effects of ethylene gas depend upon the stage of produce maturity, the temperature and relative humidity of the storage room, the concentration of ethylene and the exposure time to ethylene.

Ethylene is an invisible and odourless gas, however, its detrimental effects on produce can be easily misdiagnosed. Some of the undesirable effects of ethylene are:

- loss of green colour in some immature fruits (for example, cucumbers and squash) and leafy vegetables
- accelerated ripening of fruits during handling and storage
- russet spotting on lettuce
- induce bitterness (isocourmarin) in carrots
- sprouting of potatoes
- abscission of leaves (for example, cauliflower, cabbage)
- toughening of asparagus.

There are many sources of ethylene in the environment. The more important ones include internal combustion engines and ripening produce. Other sources include fluorescent ballasts, decomposing produce, cigarette smoke and rubber materials exposed to heat or UV light.

Use electric rather than gas-powered fork lifts where commodities are sensitive to ethylene. Isolate internal combustion engines from handling and storage areas. Do not let engines idle in an enclosed loading space.

Simple ventilation of handling areas can prevent ethylene build-up, as long as the incoming air is not polluted. One air exchange per hour is usually sufficient.

Ethylene can be used to your advantage when controlled and careful ripening of fruits and vegetables is desired. In this case, commercially available ethylene generators are used.

### Commodity Compatibility

Not all crops should be stored together, even if they have the same storage requirements. Some crops will give off volatile substances that interfere with the successful storage of others. For example, apples, pears, peaches, plums, apricots and tomatoes give off ethylene gas which, even in low concentrations, can cause undesirable effects in many vegetables (see the section *Ethylene*, left). Potatoes may impart an earthy flavour to fruit, particularly at high temperatures. Do not store incompatible commodities in the same building unless special ventilation requirements have been made.

### Storage Sanitation

Cleaning and sanitation in horticultural storage and packing areas to eliminate disease-causing organisms is extremely important. A good sanitation program involves three steps: cleaning, disinfecting and rinsing.

Cleaning includes removing debris, such as soil, wood, stones and metal, by brushing, vacuuming, scraping and high-pressure washing. Cleaning compounds such as soaps can be used to lower the surface tension of water so that soils may be loosened and flushed away.

## Table 4–11.
## Storage Life for Fresh Vegetables in Commercial Storage

| Commodity | Temperature °C | Relative Humidity (%) | Approximate Storage Life |
|---|---|---|---|
| Asparagus | 0–2 | 95–100 | 2–3 weeks |
| Beans, green or snap | 4–7 | 95 | 7–10 days |
| Beans, lima | 3–5 | 95 | 5–7 days |
| Beets, topped | 0 | 98–100 | 4–6 months |
| Broccoli | 0 | 95–100 | 10–14 days |
| Brussels sprouts | 0 | 95–100 | 3–5 weeks |
| Cabbage, Chinese | 0 | 95–100 | 2–3 months |
| Cabbages, early | 0 | 98–100 | 3–6 weeks |
| Cabbages, late | 0 | 98–100 | 5–11 months |
| Carrots, bunched | 0 | 95–100 | 2 weeks |
| Carrots, immature | 0 | 98–100 | 4–6 weeks |
| Carrots, mature | 0 | 98–100 | 7–9 months |
| Cauliflower | 0 | 95–98 | 3–4 weeks |
| Celeriac | 0 | 97–99 | 6–8 months |
| Celery | 0 | 98–100 | 2–3 months |
| Chard | 0 | 95–100 | 10–14 days |
| Chicory, witloof | 0 | 95–100 | 2–4 weeks |
| Collards | 0 | 95–100 | 10–14 days |
| Corn, sweet | 0 | 95–98 | 5–8 days |
| Cucumbers | 10–13 | 95 | 10–14 days |
| Eggplants | 8–12 | 90–95 | 1 week |
| Endive and escarole | 0 | 95–100 | 2–3 weeks |
| Garlic | 0 | 65–70 | 6–7 months |
| Greens, leafy | 0 | 95–100 | 10–14 days |
| Horseradish | –1.0–0 | 98–100 | 10–12 months |
| Kale | 0 | 95–100 | 2–3 weeks |
| Kohlrabi | 0 | 98–100 | 2–3 months |
| Leeks | 0 | 95–100 | 3–6 months |
| Lettuce | 0 | 98–100 | 2–3 weeks |
| Melons | | | |
| Honey Dew | 7 | 90–95 | 3 weeks |
| Muskmelons (¾-slip) | 2–5 | 95 | 15 days |
| Muskmelons (full slip) | 0–2 | 95 | 5–14 days |
| Watermelons | 10–15 | 90 | 2–3 weeks |
| Mushrooms | 0 | 95 | 3–4 days |
| Okra | 7–10 | 90–95 | 7–10 days |
| Onions, dry | 0 | 65–70 | 1–8 months |
| Onions, green | 0 | 95–100 | 3–4 weeks |
| Onions, sets | 0 | 65–70 | 6–8 months |
| Parsley | 0 | 95–100 | 2–2.5 months |
| Parsnips | 0 | 98–100 | 4–6 months |
| Peas, green | 0 | 95–98 | 1–2 weeks |
| Peppers, chili (dry) | 0–10 | 60–70 | 6 months |
| Peppers, sweet | 7–13 | 90–95 | 2–3 weeks |
| Potatoes, chipping | 10 | 90–95 | 10 months |
| Potatoes, early crop | 4 | 90–95 | 7 days |
| Potatoes, late crop | 4 | 90–95 | 5–10 months |
| Potatoes, seed | 2–4 | 90–95 | 7 months |
| Potatoes, sweet | 13–16 | 85–90 | 4–7 months |
| Pumpkins | 10–15 | 50–70 | 2–3 months |
| Radishes | 0 | 95–100 | 3–4 weeks |
| Rhubarb | 0 | 95–100 | 2–4 weeks |
| Rutabagas | 0 | 98–100 | 4–6 months |
| Salsify | 0 | 95–98 | 2–4 months |
| Spinach | 0 | 95–100 | 10–14 days |
| Squashes, summer | 5–10 | 95 | 1–2 weeks |
| Squashes, winter | 10–15 | 50–70 | 1–6 months |
| Sweet potatoes | 13–16 | 85–90 | 4–7 months |
| Tomatoes, firm-ripe | 8–10 | 90–95 | 4–7 days |
| Tomatoes, mature-green | 13–21 | 90–95 | 1–3 weeks |
| Turnips | 0 | 95 | 4–5 months |

### Table 4–12.
### Proven Disinfectants

| Sanitizing Compound | Mixing Rate With Water |
|---|---|
| Hypochlorites (bleaches[1, 2] 5.256.0% active) | 1 part to 9 parts water |
| Quaternary ammonium (10% active) e.g., DCD | 1.0 mL per 300 mL water |
| Phenolic compounds[3] (sold as hospital disinfectants) | See label. Use rate listed for heavy spills. |
| 37% formalin solution[2] | 3 L per 100 L water |

[1] Corrosive to metal surfaces.

[2] Wear a suitable respirator. Ventilate following treatment. Fumes are toxic to plants.

[3] Provides residual action.

Cleaning must be done before disinfecting. Dirt and residue will prevent the disinfectant from coming into contact with all surfaces. Many common disinfectants are deactivated by organic matter.

There are many products and procedures for sanitizing storages and equipment. See Table 4–12, *Proven Disinfectants*, left, for a short list of proven disinfectants.

**For more information on storage, consult these OMAF Factsheets:**

- *Long-Term Storage of Carrots*, Order No. 98-073
- *Storage of Cabbage*, Order No. 90-055
- *Troubleshooting Cold Storage Problems*, Order No. 94-083
- *Sizing and Laying Out a Short-Term (Summer) Refrigerated Storage for Fruits and Vegetables*, Order No. 82-124
- *Chilling Injury of Horticultural Crops*, Order No. 98-021
- *Tunnel Forced-Air Cooler for Fresh Fruits and Vegetables*, Order No. 98-031

# 5. Integrated Pest Management

Integrated pest management (IPM) is an approach to pest control that uses all available control strategies to maintain pest populations of insects, mites or disease organisms below an economic injury level. It does not advocate a continuous pesticide spray program to eradicate pests but promotes the integration of cultural, biological and chemical control strategies. By using these pest control strategies, the adverse effects of pesticides on the environment are minimized, and economic returns are maintained.

To implement an IPM program on your farm, you must have a thorough knowledge and understanding of:

- the pest – identification, biology and behaviour
- beneficial organisms
- monitoring techniques
- use and timing of appropriate management tools
- resistance management strategies
- recordkeeping.

In this publication, use and timing of chemical and cultural management tools and resistance management strategies are outlined. More detailed information on pest identification, biology, trapping, monitoring and record keeping techniques can be found in OMAF publications such as:

- Publication 700, *Integrated Pest Management for Onions, Carrots and Lettuce in Ontario:* A handbook for growers, scouts and consultants
- Publication 701, *Integrated Pest Management for Crucifers in Ontario:* A handbook for growers, scouts and consultants
- Publication 12, *Sweet Corn Production Manual.*

Current information is also available on the crop page of OMAF's Web site at www.gov.on.ca/OMAF/english/crops/index.html. Additional information is supplied via newsletters, meetings, field monitoring demonstrations and pest management workshops.

## Thresholds

An IPM program uses control guidelines (thresholds) that indicate when pesticides should be applied to prevent economic losses. Timing of control measures is critical. Guidelines for insect pests are based on an economic threshold where the lost income from not applying a control will be higher than the cost of applying a control. In other words, some damage to the crop is tolerated as long as this damage does not exceed the cost of the control. Guidelines for diseases, weeds, nematodes and vertebrates may be based on weather, site history, stage of crop development and field observations.

## Monitoring

Monitoring is critical for the successful implementation of any IPM program. Monitoring allows you to forecast and evaluate potential pest problems. Effective monitoring identifies the pest present, estimates populations and recognizes conditions favourable to pest development and damage.

Monitoring allows accurate timing of pest control measures, thus reducing pesticide use. Regular monitoring will also help identify minor/secondary pest populations before they can cause significant damage.

Monitoring can include the use of traps and/or visual scouting. For a list of monitoring equipment suppliers, see Table 5–1, *Monitoring Equipment Suppliers*, on page 42.

Good recordkeeping is essential. Keep a site map and records of:

- status of crop health
- population levels of pests and beneficials
- damage observed
- location of damage
- weather and other environmental conditions
- sprays and other control measures used.

### Table 5–1.
### Monitoring Equipment Suppliers

| Company | Address | Phone | E-mail/Web site |
|---|---|---|---|
| Cooper Mill Ltd. | R. R. # 3<br>Madoc, ON K0K 2K0 | (613) 473-4847 | e-mail: ipm@coopermill.com<br>www.coopermill.com |
| Gempler's | 100 Countryside Dr.<br>Belleville, WI 53508 | 1-800-383-8473 | www.gemplers.com |
| Great Lakes IPM | 10220 Church Rd., NE<br>Vestaburg, MI 48891 | (989) 268-5693 | e-mail: glipm@nethawk.com<br>www.greatlakesipm.com |
| Natural Insect Control | R. R. # 2<br>Stevensville, ON L0S 1S0 | (905) 382-2904 | e-mail: nic@niagara.com<br>www.naturalinsectcontrol.com |
| PheroTech | 7572 Progress Way<br>Delta, BC V4G 1E9 | (604) 940-9944 | e-mail: sales@pherotech.com<br>www.pherotech.com |
| Plant Products Co. Ltd. | 314 Orenda Rd. E.<br>Brampton, ON L6T 1G1 | 1-800-387-2449 | e-mail: sales@plantprod.com |
| N.M. Bartlett Inc. | 4509 Bartlett Rd.<br>Beamsville, ON L0R 1B1 | (905) 563-8261 | www.bartlett.ca |
| Solida Distributors | 480 Rang St-Antoine<br>St. Ferreol-les-Neiges, PQ G0A 3R0 | (418) 826-0900 | e-mail: solida@clic.net |
| Warwick Orchards and Nursery | R. R. # 8<br>Watford, ON N0M 2S0 | (519) 849-6730 | |

## Trapping

Pheromone traps are used to collect information on the activity patterns of specific insect populations. Traps are useful for indicating the presence or absence and the relative abundance of several flying insects. However, they often catch only the adult stage of the pest and may not provide information on the damaging larval stage. Weather monitoring can improve trapping efficiency by predicting insect emergence and disease forecasting.

Traps are usually placed in the field 1 to 2 weeks prior to the estimated emergence of the insect. The number of traps used and the location of the traps within the field varies with the crop and insect being monitored. Specific monitoring guidelines are available in the publications listed at the beginning of this chapter.

Keep in mind that pheromone lures are specific to the pest being trapped. They are very sensitive to contamination if they come into contact with other types of pheromones. If your trapping program involves using different types of pheromones, wear disposable latex gloves to prevent cross-contamination during handling.

## Scouting

Visual inspections keep track of insects or the amount of disease actually present in the crop. Weed counts taken across the field will aid in the selection of weed management strategies. When scouting the crop, inspect plants in several areas across the field for an accurate idea of pest pressure. Tools such as a hand lens or sweep nets can improve scouting efficiency. Special attention is often given to monitoring border areas and fencerows. These areas are favoured overwintering sites for many insect pests.

Scout fields at least once a week. More frequent monitoring is recommended when the pest is most active.

**For a list of available crop consultants providing monitoring services, contact OMAF's Agricultural Contact Centre at 1-877-424-1300, or the nearest OMAF Resource Centre.**

## Pest Control Measures

### Cultural and Mechanical

Integrated pest management incorporates cultural and mechanical practices to prevent or delay the development of pest outbreaks. Management tools include:

*Site Selection:* Avoid locations known to be favourable for pest development.

*Crop Rotation:* Many insects and diseases overwinter in crop refuse. Rotating to a non-related crop will help break the pest cycle. See *Crop Rotation for Control of Diseases*, on page 43.

*Resistant/Tolerant Cultivars:* Breeding programs select varieties that are much less susceptible to disease (or sometimes insect) pressure.

***Certified, Treated Seed:*** High-quality, vigorous seed is better able to withstand adverse weather conditions at planting. Treatments reduce the likelihood of losses to seed- and soil-borne diseases and insects.

***Sanitation:*** Remove all sources of infection (including cull piles or plant refuse) from the field or greenhouse. Use sterile growing media for transplants.

***Eliminate Alternate Hosts:*** Weeds often act as alternate hosts to many crop pests. Maintain good weed control in and around the crop.

***Inter-Cropping:*** Non-related crops planted in close proximity often act as a barrier to insects and diseases.

***Water Management :*** Avoid poorly drained locations. Timely irrigation will supply the crops needs without exposing it to unnecessary levels of soil and leaf wetness.

***Optimize Plant Health:*** Ensure rapid germination by planting into appropriate environmental conditions. Manage nutrients to ensure a vigorous plant, without contributing to excess top growth. Windbreaks can protect the crop from sandblasting and early-season damage. Avoid compacted locations.

### Crop Rotation for Control of Diseases

**Crop rotation can be an important practice for preventing some diseases caused by fungi, bacteria and nematodes. Rotation with a non-susceptible crop for 2–3 years usually allows enough time for plant material in the soil to completely decompose. In the absence of susceptible plant material, these organisms die off. This type of rotation works only when successive crops are not susceptible hosts. It is important to remember that plants in the same family (for example, potatoes, tomatoes, peppers and eggplant) may all be susceptible to the same disease organisms. Do not rotate with plants in the same family.**

**Diseases that are spread by wind or by insects are generally not controlled by rotation. Many leaf blight organisms and powdery mildew fungi can blow into fields from neighbouring weeds and fields that are infested. Virus diseases that are spread by aphids, bacterial wilt of cucumbers spread by the cucumber beetle and aster yellows, which is spread by leafhoppers, cannot be controlled by rotation. Resistant varieties, seed treatments and other methods may be used to manage these diseases.**

### Chemical Controls

Chemical controls include synthetic, inorganic and biological pesticides. They kill target pests and limit subsequent populations. They are important tools for crop protection when used as part of an IPM program.

Understand the pest's life cycle and apply chemicals at the stage when the pest is most vulnerable. To control insects, monitor fields closely and spray according to action thresholds established for each insect. To control disease, apply protective fungicides when weather conditions are favourable and before damage occurs.

### Beneficials

Beneficials are natural enemies of the crop pest. These predators (including parasites and pathogens) help suppress pest populations.

These agents will not eliminate damage by pests. However, once they are established, they can maintain pest populations at lower levels. They are also effective at controlling indirect pests such as aphids, leafhoppers and mites. They are less effective at keeping populations of direct pests (those attacking the harvested product) at levels acceptable for commercial production. One of the advantages of beneficial insects is that their activities can prevent or delay the development of pesticide resistance.

……

## Resistance Management

Pests are said to be resistant when they are able to survive exposure to rates of pesticides that previously controlled them. Generally, resistance to a pesticide develops after repeated exposure to a specific chemical. Resistance occurs because a few naturally occurring resistant individuals survive after each spray, while the susceptible portion of the population is killed. These resistant survivors multiply and gradually replace the susceptible ones. Eventually the resistant population dominates, and the pesticide loses efficacy.

Resistance to pesticides can develop very quickly. Do not use the same chemical repeatedly unless it is used in rotation with a different chemical or used in combination with other chemicals having a different mode of action.

Many chemicals with the same active ingredients are marketed under different brand names. For example, the chemical cypermethrin is marketed under the brand names Ripcord and Cymbush. Different chemicals may also have the same mode of action. For example, both Benlate and Senator act on the same site in the fungus and, therefore, have the same mode of action. Using Benlate after Senator is equivalent to using Benlate after Benlate, since resistance develops to both chemicals at the same time, even though only one may have been used repeatedly. The same applies for many pyrethroids.

The pest control recommendation tables in Chapter 6, *Crop Management Recommendations*, list the chemical family for each control product. Over the course of the season, rotate between products from different chemical families.

## General Insects and Diseases of Vegetable Crops

There are a number of pests that attack a wide range of crops. Descriptions of the pests and cultural control methods are listed here. For chemical control methods, refer to the individual commodity sections in Chapter 6, *Crop Management Recommendations.*

### Damping-Off of Seedlings

Seedlings are affected by damping-off rot at ground level and topple over. The damping-off fungus may cause seed decay also.

Sterilize flats and soil for growing seedlings (see the section *Vegetable Transplants*, on page 151). For direct-seeded crops, treat seeds with a protectant fungicide.

**Caution**

**Carefully follow the manufacturer's directions for the use of soil fumigants. You must have a permit to apply methyl bromide. A permit may be obtained from the Pesticides Control Section, Ministry of the Environment and Energy, 135 St. Clair Ave. W., Toronto, M4V 1P5, Telephone (416) 323-5095.**

### Bacterial Diseases

Bacteria are microscopic organisms that cause significant damage to vegetable crops. Bacterial blight in beans, black rot in cole crops, angular leaf spot and bacterial wilt in vine crops, bacterial spot in peppers, blackleg in potatoes and bacterial speck, spot and canker in field tomatoes are examples.

Bacteria spread passively, for example, through splashing water, violent windstorms, insects such as the cucumber beetle, animals (including humans) and machinery moving through wet fields — especially when the foliage is wet, such as in the morning under heavy dew conditions.

Infected seeds are the primary source of bacterial disease introductions. Even as few as 1 in 30,000 infected seeds, a level often beyond the detection ability of most laboratories, is enough to cause disease outbreaks. Bacteria can also survive for short periods of time on crop debris in the soil, on benches, trays, etc.

Control of bacterial diseases has been based on seed treatments. Fermentation, hot water, chlorine and acid treatments have been tried on different seed types. For more information on treating seed, see the section *Vegetable Transplants*, on page 151. Unfortunately, even under the most rigid treatment protocols, a small portion of diseased seed can still lead to significant problems in the field.

Successful management of bacterial diseases includes clean seed, clean transplants, resistant cultivars, appropriate spray programs, reducing crop stress and limiting the spread within fields by only working in the field when the foliage is dry.

### Cutworms

Several species of cutworms attack vegetables. Dark-sided, red-backed, black and glassy cutworms appear early in the growing season. Depending on soil and climatic conditions, these species will attack the plants below or at the soil surface. The variegated cutworm, which is a foliage feeder, usually causes late-season damage.

Effective cutworm control is dependent on proper timing of insecticide applications under favourable soil and climatic conditions. Many of the insecticides registered for cutworm control are short-residual and breakdown quickly in sunlight.

Most species of cutworms go into the soil during the day and come out to feed at night. Insecticide applications should be made in late afternoon or early evening, just before the insects come up to feed. Insecticides are more effective on moist soil than on dry soil.

### Wireworm

Wireworm is more likely to be a problem for the first 2 years following sod. Controlling wireworm is difficult and may take several growing seasons. Refer to the individual commodity sections of Chapter 6 for a list of registered seed treatments. Slow-emerging crops are more vulnerable to wireworm damage. Plant into well-prepared, warm soils. Avoid unnecessarily deep planting depths.

## Slugs

Slugs feed above or below ground, depending on the moisture level. They can feed on germinating seeds and seedlings, with no real preference for a plant part. Slug damage is most severe in years when there is prolonged cool, wet weather during May and June.

Cultivating fields where slugs are a problem can help reduce the slug population. Tillage exposes the slugs to dehydration and predation by birds and mammals. Removing weeds and crop residue from the zone surrounding young seedlings may also help reduce damage.

## White Grubs

To avoid injury by white grubs, wait 2 or more years before planting vegetables on land that had been planted with grass sod.

## Seedcorn Maggot

Maggots are usually a problem in direct-seeded crops during cool, wet springs when germination is delayed. The maggots feed on the swollen, ungerminated seed.

Adult flies lay their eggs from April until the middle of June. The females are attracted to moist soils that give off an odour of decaying organic matter. Fields with high residue levels or where manure has recently been applied are good potential egg-laying sites. Apply and incorporate manure well in advance of planting. Refer to the individual commodity sections in Chapter 6 for a list of registered insecticidal seed treatments.

## Nematodes

Root-lesion, root-knot and sugar beet cyst nematodes are responsible for most nematode problems in Ontario vegetable crops. A crop may be attacked by the combined action of two or more kinds of nematodes. In some cases, nematodes aggravate diseases caused by fungi (for example, root-lesion nematodes worsen verticillium wilt of eggplants, tomatoes and potatoes). In potatoes, the verticillium-nematode complex is involved in the potato early-dying problem.

### *The Root-Lesion Nematode*

Common in Ontario, this nematode has a very wide host range that includes most vegetables, strawberries, corn, legumes and tobacco. It causes tiny, brownish, scratch-like wounds on the roots and is very destructive to crops such as celery and lettuce.

### *The Root-Knot Nematode*

Frequently found in vegetable-producing areas, particularly in muck soils and greenhouses, these nematodes cause galls on the roots, resulting in poor plant growth that quite often shows up as patchy areas in a field. Many crops are attacked by this nematode, sometimes resulting in severe losses, particularly with carrots. The southern root knot species may be imported on transplants.

### *The Sugar Beet Cyst Nematode*

This nematode is quite destructive to beets and spinach, but other root and cruciferous crops are also affected. It is frequently found in association with rhubarb. This nematode can be seen on the roots as tiny, white or brown, pearl-shaped objects.

### *The Bulb and Stem Nematode*

Several races of this nematode have been identified in other parts of the world. Many races are host-specific, while others infect multiple hosts. The races that infect carrots have not been found in Ontario.

This nematode causes onion bloat and has been found in several of the onion-growing areas. Onion bloat symptoms may appear early in the crop when leaves become twisted and deformed. Infected plants that survive are usually deformed, with shorter, thickened leaves. Splitting and cracking of infected bulbs is one of the most easily recognizable symptoms.

Practical control measures depend largely on the limited host range of the Ontario population of this nematode as well as sanitation, soil fumigation and crop rotation.

**Note**

**Before deciding upon a management strategy for nematodes, a nematode soil test must be completed to correctly identify the type and level of nematode that may be present. See Appendix G, *Diagnostic Service*, on page 286, for sampling and testing information. Consideration of past, present and future crops should be included.**

### *Nematode Control*

An integrated approach combining crop rotation, nematode-suppressing cover crops, cultivation practices and fumigation is recommended.

The chemicals most commonly used in preplant soil fumigation for nematode control are Busan 1020, Telone II, Telone C-17 and Vapam. In Ontario, custom operators do much of the soil fumigation against nematodes. Fumigants are either broadcast applied, banded in beds or injected into the soil, depending on the nematode problem, soil type and chemical used. Muck soils often require higher rates. Always follow the instructions on the label carefully regarding rates and application method.

Shank-injection of fumigants is preferable to reduce the chance of wind-and-odour drift, run-off or other mishaps.

Soil can be fumigated either in the fall or in the spring.

At the time of fumigation, the soil temperature should be at least 4°C at the 15-cm depth, the soil must be thoroughly worked to a depth of 20–25 cm and the moisture content of the soil must be at a level that would permit good seed germination. With fall applications, the soil should be worked several weeks before fumigation so that the area is reasonably free from undecomposed crop residue. For more information, refer to the OMAF Factsheet, *Land Preparation — A Key to Successful Soil Fumigation*, Order No. 89-177.

Before planting, till the soil thoroughly to aerate and ensure that all traces of fumigant odour have dissipated. With fall applications, the soil should not be disturbed after sealing until the normal spring cultural operations are started. Growers should wait at least 2 weeks before planting into spring-fumigated soil.

Methyl bromide and high rates of Vapam and Busan are used as general-purpose soil fumigants. Do not use nematicides containing bromine before planting onion, beet, celery or potato. Methyl bromide must be applied under a plastic cover according to the manufacturer's directions.

A permit is required to apply methyl bromide. See *Caution*, on page 44.

## Deer, Groundhogs and Rabbits

Deer, groundhogs and rabbits can be a serious problem in vegetable plantings, particularly in areas where woodlots or other brush surround vegetable fields. Deer and groundhogs will often root for carrots in harvested fields. Trapping groundhogs and moving them to other areas may reduce the problem.

Hinder is registered as both a deer and rabbit repellent. It can be applied using normal field spraying equipment. The rate to use depends on the severity of the problem. Hinder, at 2–4 L/100 L should be applied at a volume of 450–950 L of water/ha (180–380 L/ac). This results in an actual application range of 9–39 L of Hinder product/ha (3.6–15.6 L/ac).

Hinder acts as a scent repellent. It is important that the edges of the affected fields, particularly areas where the deer or rabbits enter, be thoroughly covered with spray solution. For more information on deer control, see OMAF Publication 10, *Deer Control Practices in Agriculture*.

# 6. Crop Management Recommendations

## ASPARAGUS

### Cultivars

Consult plant suppliers for descriptions of varieties and availability of plants 1 year in advance of planting. Consult the Ontario Asparagus Grower's Marketing Board for seed availability.

#### *All-Male Hybrids*

**Guelph Millennium**

This hybrid produced marketable yields higher than Jersey Giant in research station trials. It is more susceptible to rust and requires more intensive disease management than the Jersey varieties.

**Jersey Giant**

Jersey Giant produces good, marketable yields and has good rust tolerance.

**Jersey Knight**

Jersey Knight produces good, marketable yields and has good rust tolerance.

### Field Selection and Preparation

Asparagus is a long-term vegetable crop that should produce viable yields for 15 or more years. Therefore, thorough planning is essential for success.

Field selection and preparation are important for long-term production. Plant only into well-drained sandy or sandy loam soil free of perennial weeds and grasses. Soil testing is highly recommended to determine fertility levels and pH before transplanting. Ideal soil pH should range between 6.0 and 6.8. If possible, seed a green-manure crop the year before transplanting to increase soil organic matter. Livestock manure can also be used.

Avoid planting asparagus into fields that have previously grown asparagus. Asparagus yields decline over time due to two important *Fusarium* diseases that are commonly found in asparagus soils.

1. *Fusarium oxysporum* is found in all soils, all the time, so its presence cannot be avoided. However, the concentration or level of this disease will increase in soils where asparagus plants become infected. Once an asparagus field has been taken out of production, it usually takes about 5 years for the disease level to decrease to its "normal" or base concentration.
2. *Fusarium moniliforme* is a soil-borne disease that can be hosted by both asparagus and corn. Avoid planting asparagus in fields where corn has been grown in the previous 3 years.

### Growing Seedlings

Soak seed in approximately 32°C water for 3–4 days. Dry and sow immediately in fertile, well-prepared soil. Date of seeding is about mid-May or once the ground is prepared and warm enough for seedings. One kilogram of good seed should provide enough crowns to plant 1 ha (0.89 lb/ac). To allow for selection of strong plants, plan to grow more plants than is needed.

**Row spacing:** 45–60 cm (18–24 in.)
**In-Row spacing:** 8–10 cm (3–4 in.)
**Depth:** 2.5–4 cm (1–1.5 in.)
**Rate:** Approximately 11 kg of seed/ha (10 lb/ac)

### Transplanting and Spacing

Dig the 1-year-old nursery plants in early spring. Discard the weak or small crowns (less than 20 g). Up to one-third of the total crowns may be discarded. Cover crowns immediately, level with the surrounding soil surface and firm with packing wheels.

**Row Spacing:** 1.2–1.5 m (4–5 ft)
**In-Row Spacing:** 22–30 cm (9–12 in.)
**Depth:** Top of crown: 15 cm (6 in.) deep

### Harvest of Spears

Healthy asparagus plantings can be harvested for about 10–14 days at the beginning of the third season after field setting. For example, if the field is set in the spring of 2002,

### Table 6–1.
### Rust Control Recommendations for Asparagus

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | Notes |
|---|---|---|---|---|---|
| zineb | dithiocarbamate | Zineb 80 WP | 2.5–2.75 kg | 1–1.1 kg | |
| metiram | dithiocarbamate | Polyram 80 DF | 2.25–3.25 kg | 1–1.3 kg | Use high rate on full-grown fern. |
| myclobutanil | triazole | Nova 40 W | 340 g in 370 L water | 136 g in 150 L water | Maximum 5 applications/yr. |
| propoconazole | triazole | Topas 250 E | 250 mL | 100 mL | Maximum 3 applications/yr. |

the first limited harvest would be in the spring of 2004. The harvest season is increased by 1–2 weeks per year.

The length of the harvest season is determined by plant vigour and spear size. Stop harvesting when 75% of the spears are smaller than 1 cm (⅜ in.) in diameter. As a general rule, do not extend the harvest period beyond 6 weeks. If weeds, insects, disease or adverse weather conditions reduced plant vigour in the previous season, reduce the harvest duration.

An average harvest should be in the range of about 100 kg/ha (89 lb/ac) per picking. With an average of 30 harvest days/season (for fully mature plantings), economic yields should be about 3,000 kg/ha (2,670 lb/ac).

## Tillage and Fern Disposal

Clip asparagus fern in the fall, leaving 15–20 cm of stubble to catch drifting snow for better crown protection. The stubble can be cut up with a rotary or flail-type mower in early spring.

The fern contributes organic matter to the soil and helps to prevent early-season wind erosion. Avoid unnecessary tillage and use zero tillage practices where possible. Excessive and deep tillage can injure crowns, which can increase *Fusarium* infection and reduce yields.

Fall-seeded cover crops help maintain soil organic matter, while preventing both water and wind erosion. Broadcast 4 bu/ha of rye in late August to mid-September. Apply a burn-down herbicide in the spring.

## Fertility

### Nitrogen

*Nursery:* Apply up to 75 kg nitrogen/ha. Broadcast the nitrogen with all of the phosphate and potash required and work in before seeding. An additional 50 kg nitrogen/ha may be applied as a side-dress application in August or early September if rainfall was excessive in the summer.

**Green manure crops planted in the year prior to asparagus establishment require 30–40 kg nitrogen/ha prior to or at seeding. Apply P and K based on crop requirements and soil tests.**

*New plantings (crowns):* Broadcast 110 kg nitrogen/ha with the potash prior to planting. The phosphate should be banded below the crowns at planting.

If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

*Established plantings:* Broadcast 55 kg nitrogen/ha with all of the phosphate and potash required in early spring. Broadcast an additional 55 kg nitrogen/ha immediately after harvest.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.) Take the soil sample at the depth of planting.

## Disease Management

Consult the OMAF Factsheet, *Diseases of Asparagus*, Order No. 82-045.

### Rust

All commercial cultivars are susceptible to rust. However, some varieties do have moderate levels of rust resistance. Disease control is achieved only with thorough spray coverage on a regular preventive schedule. This spray must protect new foliage as it grows, before rust spores can land on it and germinate.

Start spraying new, non-harvested plantings as soon as growth is about 30 cm high (late May). For harvested plantings, begin spraying as soon as fern growth commences after harvest is complete. A 7- to 10-day schedule is essential until at least late August to protect the fern growth. A high-boy sprayer with drop arms and 3 nozzles/row is needed for full spray coverage. Spray with one of the fungicides described in Table 6–1, *Rust Control*

### Table 6–2.
### Insect Control Recommendations for Asparagus

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Aphids** | | | | | | |
| pirimicarb | carbamate | Pirimor 50 DF | 1 kg in 675 L of water | 0.4 kg in 270 L of water | | Post-harvest only |
| dimethoate | organophosphate | Lagon 480 E | 2.3 L in 675 L of water | 0.9 kg in 270 L of water | | |
| **Asparagus Beetle** | | | | | | |
| deltamethrin | pyrethroid | Decis 5 EC | 200 mL | 80 mL | | Post-harvest only. |
| cypermethrin | pyrethroid | Cymbush 250 EC | 140 mL | 56 mL | 1 | |
| carbaryl[2, 3] | carbamate | Sevin XLR plus | 2.5–6.4 L | 1–2.56 L | 2 | Do not treat more than once every 3 days. |
| methoxychlor | diphenylethane | Methoxychlor 240 | 4–10 kg | 1.6–4 kg | 3 | |
| malathion | organophosphate | Malathion 500 E | 2.5 L | 1 L | 1 | |
| | | Malathion 25 W | 5.5 kg | 2.2 kg | 1 | |
| rotenone | botanical | Rotenone 5% WP | 6 kg | 2.4 kg | 1 | Use a non-herbicidal spreader. |
| **Cutworms** | | | | | | |
| carbaryl | carbamate | Sevin XLR Plus | 2.5–6.4 L | 1–2.56 L | 2 | Late season (climbing) cutworms only. Do not treat more than once every 3 days. |
| permethrin | pyrethroid | Pounce 384 EC | 180 mL | 72 mL | 2 | |

[1] DHI = Days to Harvest Interval

[2] Use only during harvest, not during fern growth period.

[3] See the section *Bee Warning*, on page 50.

*Recommendations for Asparagus*, on page 48. Rotate between chemical groups to prevent the development of resistance.

### *Botrytis*

This disease attacks plants that have been damaged by rust or beetle feeding. Under wet weather conditions, it can cause serious plant injury. A regular spray program for rust and good control of beetles before extensive feeding occurs is the best control recommendation.

### *Crown Rots (Fusarium)*

Avoid replanting on land that previously grew asparagus. Otherwise, fumigate the soil before planting. Consult the manufacturer's directions. Follow all safety precautions.

Use only healthy, vigorous 1-year-old crowns for transplanting. Vigorously growing asparagus plants are less susceptible to crown rots. Care should be taken to avoid stressful growing conditions caused by overpicking, pest pressure, weed competition, soil compaction and low fertility.

### *Purple Spot (Stemphylium)*

This fungal disease results in purple spots, often only on the windward side of the spear. Sandblasting will pit young asparagus spears, allowing fungal spores a point of entry into the stem. This disease tends to be more prevalent during colder harvest seasons. It does not affect the internal tissue of the spear, but infected spears may be unmarketable. Purple spot can also infect fern growth during wet and humid weather, causing mild to severe discolouration of mature plants.

There seems to be no effective chemical control for this disease. However, minimizing sandblasting will help reduce the incidence of this disease. Where infection has been severe, consider destroying infected fern and plant debris, which are sources of overwintering spores.

## Insect Management

### *Asparagus Beetle*

Because there are several generations of these beetles, they are a constant threat throughout the season. If monitoring indicates a need, spray with one of the pesticides described in Table 6–2, *Insect Control Recommendations for Asparagus*, above.

### *Cutworms*

Most cutworms hide in the soil during the day and emerge to feed at night. Chemical controls are most effective if applied to moist soil in the early evening. Apply one of the pesticides described in Table 6–2, above, at the first sign of cutworm feeding. For more information, refer to the section *Cutworms*, on page 44.

### *Aphids*

Asparagus aphids are a sporadic pest in Ontario. Sprays should only be used during a non-producing season or as a post-harvest treatment. If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–2, *Insect Control Recommendations for Asparagus*, on page 49.

### *Pigweed Casebearer*

Control pigweed completely in the planting and in headlands as casebearers that develop on pigweed may contaminate the crop in May and early June the following year.

### Bee Warning

Dimethoate is toxic to bees and should not be used during the bloom period. Carbaryl is especially toxic to bees and should not be used during the fern-growth period. With other insecticides, losses to bees can be reduced if sprays are applied in early morning or late evening when the bees are not foraging. Advise local beekeepers of spraying activity (see the section *Prevent Bee Poisoning*, on page 6).

## Mechanical Injury

### *Hooking*

Bent spears are caused by injury to the spear, either above or below ground. Spears will "hook" into prevailing winds where sandblasting is a problem. Below-ground injuries causing hooking include cutworm feeding, inadvertent nicks from cutting knives and abrasions from sharp stones, cultivators, etc.

## Physiological Disorders

### *Hollow Stem*

This problem tends to be more prevalent in young spears during periods of warm, wet weather resulting in very rapid spear growth. Seasons with moderate temperatures and even growth will result in a low incidence of hollow stems. Although this problem does not affect the eating quality of the spear, some may find its appearance objectionable.

## Storage of Spears

Freshly harvested asparagus is very perishable and loses quality rapidly. Collect the spears as soon as possible, protect them from the sun and move them to cold storage, the processor or a market as soon as possible. If short-term storage is necessary, store under high humidity at 1°C–2°C. Hydrocooling is the most effective and rapid way of removing field heat from asparagus spears.

**Check out the section *Food Safety, on page 37*, for suggested Best Management Practices to minimize the risks on your farm.**

# BEANS

## Cultivars

Table 6–3, *Bean Cultivars With Disease-Resistant Traits*, below, lists varieties with disease-resistant traits available in the market. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

**Table 6–3.
Bean Cultivars
With Disease-Resistant Traits**

| Cultivar | Seed Company | Maturity (Days) | Notes |
|---|---|---|---|
| **Green Beans – Bush type** | | | |
| Espada | Harris-Moran | 53 | Resistant to bean common mosaic virus |
| Rapids | Rupp | 48 | Resistant to bean common mosaic virus and rust |
| **Green Beans – Bush type for shipping** | | | |
| Storm | Seedway,<br>Norseco,<br>Stokes | 50–51 | Resistant to bean common mosaic virus and rust |
| Rhapsody | Seedway | 50 | Resistant to bean common mosaic virus and rust |
| **Wax (Yellow) Beans** | | | |
| Rocdor | Harris-Moran,<br>Stokes | 53 | Resistant to bean common mosaic virus |
| Gold Mine | Rupp,<br>Norseco,<br>Stokes | 53–58 | Resistant to bean common mosaic virus |
| **Lima Beans** | | | |
| Baby Lima 878 | Seedway | 80 | Tolerant to downy mildew |
| Eastland | Stokes | 70 | Tolerant to downy mildew |
| **Specialty Beans —French** | | | |
| Marseille | Harris-Moran | 52 | Resistant to bean common mosaic virus |
| Tavera | Johnny's | 54 | Resistant to bean common mosaic virus |
| **Specialty Beans – Romano** | | | |
| Primo | Harris-Moran | 53 | Resistant to bean common mosaic virus and rust |
| **Processing** | As recommended by processor | | |

**Table 6–4.
Spacing and Seeding Rates for Snap Beans**

| Row Spacing cm (In.) | Plants per Metre of Row | Harvest Method |
|---|---|---|
| 75–90 (30–36) | 20 to 24 | Hand harvest or mechanical |
| 50–60 (20–24) | 16 to 22 | Mechanical |

## Spacing and Seeding

### *Lima Beans*

Use 55–65 kg (49–58 lb/ac) of seed /ha. Seed approximately 4–5 cm (1.5–2 in.) deep depending on soil moisture. Rows are spaced 60–70 cm (24–28 in.).

### *Snap Beans — Green and Yellow (Wax)*

Sow as shallow as soil moisture permits, usually 2.5–4 cm (1–1.5 in.) deep. Planting should begin only after soil temperature has reached 15°C. At lower temperatures, seed decay may reduce stand.

The row spacings and seed rates in Table 6–4, *Spacing and Seeding Rates for Snap Beans*, above, are suggested for optimum yields depending on the harvest method. Because seed size varies greatly between cultivars, the seeding rate must be adjusted by seed count. Seeding rates must also be adjusted according to germination percentage and soil temperature at planting. Increase seeding rate slightly if seeding in cool soils to compensate for reduced stands. **Note:** Dark-coloured seeds have better cold soil emergence.

## Fertility

### *Nitrogen*

Apply 30–40 kg nitrogen/ha prior to planting. This may be applied as a preplant broadcast application or banded through the planter, 5 cm below and 5 cm to the side of the seed. Side-dressing of nitrogen is only recommended following heavy rains if foliage shows nitrogen deficiency. Over-application of nitrogen will cause excess leaf growth resulting in uneven maturity.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.) Fertilizer may be broadcast before seeding and worked in or banded 5 cm below and 5 cm to the side of the seed. Because high rates of banded potassium can

### Table 6–5. Bean Seed Treatments

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| **Insecticide and Fungicide Combinations** | | | | |
| Agrox B-3 | diazinon-lindane-captan | 80 g per 25 kg seed | Seed and root maggots, wireworms, seed decay and damping-off | Do not use on seed already treated with an insecticide. |
| Agrox D-L plus | diazinon-lindane-captan | 50 g per 25 kg seed | Seed and root maggots, wireworms, seed decay and damping-off | Use on seed previously treated with captan or thiram.<br>Do not use on seed already treated with an insecticide. |
| DLC | diazinon-lindane-captan | 50 g per 22.7 kg seed | Seed maggots, wireworms and seed rot | Use on seed previously treated with captan or thiram. |
| **Fungicide Only** | | | | |
| Apron XL LS | metalaxyl-m | 20–40 mL per 100 kg seed | Damping-off and root rot | For use in commercial seed treatment plants only. |
| Captan FL | captan | 70 mL per 25 kg seed | Seed decay, damping-off and root rot | For use in commercial seed treatment plants only. |
| Thiram 75 WP | thiram | 25–35 g per 25 kg seed | Seed decay and damping-off | Do not feed treated clippings to livestock |

damage emerging seedlings, banded potassium should not exceed 60 kg potash/ha.

### *Micronutrients*

#### Boron

Beans are very sensitive to boron toxicity and should not be grown the year after boron has been applied to previous crops such as cole crops, celery or rutabaga.

#### Manganese

Manganese deficiency may be a problem on beans, especially on soils with pH values above 6.5. Correct the deficiency as soon as detected with a foliar manganese spray. Soil application is not recommended for manganese because of the large amounts required. Consult the section *Manganese*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Zinc

Zinc deficiency in beans is rare in Ontario, but it has been reported in other areas.

## Disease Management

### *Pythium Damping-Off and Phytophthora Root Rot*

Use fungicide-treated seed (see Table 6–5, *Bean Seed Treatments*, above) to minimize damping off. Rotate beans with non-leguminous crops and ensure good drainage in the field.

Root rots are most likely to occur during periods of warm, wet weather. See Table 6–6, *Disease Control Recommendations for Beans*, on page 53.

### *Anthracnose and Bacterial Blight*

The Western U.S. is the best source of anthracnose- and blight-free seed. Rotate fields away from all types of beans and peas for at least 3 years. Table 6–6, *Disease Control Recommendations for Beans*, on page 53, shows protectants that help manage bacterial blight.

### *Viruses: Common Mosaic (CBMV), Bean Yellow Mosaic and Cucumber Mosaic*

These viruses are spread by aphids. Common mosaic is also seed-borne. Yellow mosaic overwinters in forage legumes and sweet clover. Avoid planting beans adjacent to hayfields.

Control of aphids will not usually prevent the spread of these viruses. Resistant varieties are the best means of control. Consult with your seed supplier for a list of suitable varieties.

### *Sclerotinia White Mould, Botrytis Grey Mould*

Well-drained soils with good air circulation are less susceptible to these diseases. Avoid rotations with other susceptible crops including potatoes, tomatoes, lettuce and cabbage. Favourable conditions for disease development include cool temperatures and continuous soil wetness for 6–10 days prior to bloom.

All sprays must penetrate the crop canopy and contact blossom petals. Use of drop nozzles, overhead nozzles and high pressure give best results. Applications made after bloom are not effective. If wet weather persists, a second spray during bloom will be beneficial.

## Table 6–6.
## Disease Control Recommendations for Beans

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Bacterial Blight** | | | | | | |
| copper hydroxide | inorganic | Parasol | 2.25–3.25 kg | 1–1.3 kg | 1 | |
| **Botrytis Grey Mould, Sclerotinia White Mould[2]** | | | | | | |
| benomyl | benzimadazole | Benlate 50 WP | 2.25 kg | 0.9 kg | 14 | Spray at first bloom. |
| dicloran | quinone | Botran 75 W | 3.25 kg | 1.3 kg | 2 | Spray at first bloom.<br>Do not feed treated foliage to livestock. |
| iprodione | dicarboximide | Rovral WP | 1.5 kg | 0.6 kg | 15 | Spray at 50% bloom.<br>Aerial application permitted. |
| vinclozolin | dicarboximide | Ronilan EG | 1.0–1.5 kg | 0.4–0.6 kg | 14 | Spray at first bloom. Max 2 applications per year. |
| **Pythium Damping-off, Phytophthora Root Rot** | | | | | | |
| metalaxyl-M | acylamine | Ridomil Gold 480 EC | 300 mL[3] | 120 mL | | Snap beans only. Apply only once per year at planting. |

[1] DHI = Days to Harvest Interval

[2] For snap beans grown in fields recently affected by white mould.

[3] Based upon 2.3 mL per 100 m of row using a 20-cm spray band and a 76-cm row spacing.

### *Alternaria Pod Spot*

Alternaria pod spot causes rust-coloured flecks on mature pods. It tends to be more prevalent during late summer. Yellow wax beans and some varieties of green beans such as Strike are very susceptible.

## Insect Management

### *Seedcorn Maggot, Wireworm and Seed Decay*

Plant seed no deeper than 4 cm (1.5 in.) to promote rapid germination. Fresh manure and rotting organic matter attract seedcorn maggot flies in the early spring. Incorporate manure promptly to discourage egg-laying. Wireworms are most likely to be a problem for the first 2 years following sod. Use the seed treatments listed in Table 6–5, *Bean Seed Treatments*, on page 52.

### *Leafhoppers*

Leafhoppers generally spend the early part of the season in hay fields. They will migrate into beans at first cut. Feeding damage (hopperburn) is often confused with drought stress. Plants are most susceptible to leafhopper damage prior to bloom. Low levels of hopper feeding on emerging seedlings can have a severe impact on yield.

Keep a close eye on beans located close to hay fields. A spray is warranted if there are more than 2 adults per foot of row at the seedling stage. For later growth stages, the threshold is 5 adults per foot of row. See Table 6–7, *Insect Control Recommendations for Beans*, on page 54.

### *Mexican Bean Beetle*

The spray threshold for this pest is 20% defoliation prior to bloom and 10% defoliation during pod-fill. Excessive defoliation from this pest will result in early maturity and yield losses.

### *Green Cloverworm, Aphids and Spider Mite*

If crop monitoring indicates, spray with a pesticide recommended in Table 6–7, *Insect Control Recommendations for Beans*, on page 54.

### *European Corn Borer*

In snap beans, corn borer larvae feed briefly on the leaves but soon begin tunnelling into the stems and pods. Since much of the pod damage is internal, with only a small entry hole visible on the outside, grading out infested pods is very difficult. Corn borers cause problems in snap beans used for processing as larvae feeding on pods may show up in the finished product.

The risk of damage increases when the corn borer population is high and other host plants are not available. Protect the snap beans with regular insecticide sprays, starting when the beans begin flowering. For control options, see Table 6–7, *Insect Control Recommendations for Beans*, on page 54.

For more information, consult the OMAF Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

## Table 6–7.
## Insect Control Recommendations for Beans

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Aphids** | | | | | | |
| dimethoate[2] | organophosphate | Cygon 480 E[2] | 0.7–1 L | 0.28–0.4 L | 7 | |
| | | Lagon 480 E[2] | 0.7–1 L | 0.28–0.4 L | 7 | Snap beans only.<br>Aerial application permitted. |
| malathion | organophosphate | Malathion 500 E | 1.5–2.75 L | 0.6–1.1 L | 3 | |
| naled | organophosphate | Dibrom | 1.1–2.2 L | 0.44–0.88 L | 4 | Lima beans only. Aerial application permitted.<br>Do not apply when temperature is > 32°C. |
| **Corn Borer** | | | | | | |
| permethrin | pyrethroid | Pounce 384 EC | 260 mL | 104 mL | 7 | Aerial application permitted.<br>Maximum 2 aerial applications per season. |
| methomyl | carbamate | Lannate SP | 550 g | 220 g | 7 | Minimum period for re-entry is 24 hours. |
| carbaryl | carbamate | Sevin XLR plus | 5.25 L | 2.1 L | 5 | |
| **Leafhoppers, Mexican Bean Beetle** | | | | | | |
| carbaryl | carbamate | Sevin XLR plus | 1.25–2.5 L | 0.5–1 L | 5 | Use low rate on young plants.<br>Use high rate for leafhoppers. |
| endosulfan[2] | chlorinated cyclodiene | Thiodan 4 EC[2] | 1.5–2.5 L | 0.6–1 L | 2 | Do not apply on lima beans.<br>Also controls green cloverworm. |
| | | Thionex 50 WP[2] | 1.1–1.5 kg | 0.44–0.6 L | 2 | Do not apply to lima beans. |
| dimethoate[2] | organophosphate | Cygon 480E[2] | 0.7–1.0 L | 0.28–0.4 L | 7 | Also controls tarnished plant bug. |
| | | Lagon 480E[2] | 0.7–1.0 L | 0.28–0.4 L | 7 | Also controls tarnished plant bug. |
| malathion | organophosphate | Malathion 500 E | 1.8 L | 0.72 L | 3 | Mexican bean beetle only. |
| **Spider Mite** | | | | | | |
| dicofol[2] | diphenylethane | Kelthane 50 W[2] | 1.0–1.25 kg | 0.4–0.5 kg | 7 | Apply only once/season. |

[1] DHI = Days to Harvest Interval
[2] Do not graze or feed treated foliage to livestock.

### *Tarnished Plant Bug*

This pest may damage flowers and fruit leading to flower abortion and/or pin-point lesions on leaves. If tarnished plant bugs are found during monitoring, see Table 6–7, *Insect Control Recommendations for Beans*, above.

For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

## Physiological Disorders

### *Bronzing*

Bronzing is a physiological disorder caused by high levels of atmospheric ozone associated with air pollution. It usually occurs following the initiation of flowering and after the older leaves become fully mature. A bronze-coloured stipple develops on the pods and the upper surface of the leaves. Pod and seed set are usually reduced, and the plants age prematurely. Dry beans and limas appear more sensitive than snap beans, and cultivars within these types differ in susceptibility.

**Looking for new ideas for cover crops following beans?**
**See the section *Cover Crops*, on page 25.**

# BEETS, TABLE

## Cultivars

Table 6–8, *Table Beet Cultivars With Disease-Resistant Traits*, right, lists varieties with disease-resistant traits available in the market. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Field Seeding and Spacing

For a continuous supply of beets for bunching, sow seed at 2-week intervals, from early April to the end of July. For storage and processing, sow about 10 weeks before late-fall harvesting. Seed will not germinate at temperatures lower than 4°C. Optimum germination temperature is from 10°C to 29°C.

**Row Spacing:** 30–40 cm (12–16 in.)
**Rate:** 7 kg/ha (6 lb/ac)
**Depth:** 1.2–2.0 cm (0.5–0.9 in.)

Thin plants 5–8 cm (2–3 in.) apart. No thinning is required on muck soils when seeders are adjusted to ensure a stand of 32–40 plants per metre of row.

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

**Mineral soils:** Apply up to 110 kg N/ha. Broadcast and incorporate 65 kg N/ha and all of the phosphate and potash required before planting. The remainder of the nitrogen should be side-dressed.

**Muck soils:** Apply up to 40 kg N/ha.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.)

**Table 6–8.**
**Table Beet Cultivars**
**With Disease-Resistant Traits**

| Cultivar | Company | Maturity (Days) | Notes |
|---|---|---|---|
| **Bunching** | | | |
| Kestral | Rupp,<br>Norseco | 53–55 | Tolerant to cercospora leaf spot and downy mildew. Also suitable for baby beets. |
| Avenger | Seigers | 50 | Tolerant to cercospora leaf spot and downy mildew. |
| **Fresh Market** | | | |
| Action | Bejo | 60 | Resistant to cercospora leaf spot. |
| Red Ace | Norseco,<br>Seedway,<br>Bejo,<br>Siegers | 53–55 | Tolerant to cercospora leaf spot and downy mildew. |
| Scarlet Supreme | Stokes | 52–54 | Tolerant to cercospora leaf spot. |
| Red Cloud | Bejo | 53 | High sugar content. |
| **Processing** | **As recommended by processor** | | |

If phosphate and potash are required, they should be applied and incorporated prior to planting.

### *Micronutrients*

#### Boron

Boron deficiency shows up as a breakdown and corky, dark discolouration of internal tissues It is most likely to occur on alkaline soils after prolonged hot, dry periods. Consult the section *Boron*, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Manganese

Deficient plants show marked yellowing between the leaf veins; the veins themselves remain green. To correct a deficiency spray with manganese sulfate. Consult the section *Manganese*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Table 6–9.
## Table Beet Seed Treatments

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Apron XL LS | metalaxyl-m | 20–40 mL per 100 kg seed | damping-off | Export use only.<br>For use in commercial seed treatment plants only. |
| Thiram 75 WP | thiram | 90 g per 25 kg seed | damping-off | |

## Disease Management

### *Damping-Off and Seedling Diseases*

To minimize damping-off and seedling diseases, use seed treated with one of the fungicides recommended in Table 6–9, *Table Beet Seed Treatments,* above.

### *Cercospora Leaf Spot*

This disease is more of a problem on fresh, bunched beets. If monitoring indicates a need, apply fungicide as indicated in Table 6–10, *Disease and Insect Control Recommendations for Table Beets*, on page 57.

### *Pocket Rot / Root Rot*

This disease is caused by *Rhizoctonia* fungi. Symptoms vary from cankers on lower petioles and crowns to root rot of beets. The disease is more severe when long periods of wet conditions prevail. Avoid splashing soil onto beet roots and rotate with grain crops.

## Insect Management

### *Leaf Miners*

Leaf miner control is usually required only for bunching beets, where damage-free tops are required. When miners first appear, spray with one of the pesticides recommended in Table 6–10, *Disease and Insect Control Recommendations for Table Beets*, on page 57.

### *Aphids*

If monitoring indicates a problem, spray with one of the pesticides recommended in Table 6–10, *Disease and Insect Control Recommendations for Table Beets*, on page 57.

### *Webworm*

Webworms are usually only a minor problem in Ontario. On bunched beets, treatment may be warranted if more than 3%–6% of the plants are infested. See Table 6–10, *Disease and Insect Control Recommendations for Table Beets*, on page 57.

### *Cutworms*

Cutworms are only a minor problem in Ontario. Apply the treatments listed in Table 6–10, *Disease and Insect Control Recommendations for Table Beets*, on page 57, only if monitoring indicates a problem. Most cutworms hide in the soil during the day and emerge to feed at night. Chemical controls are most effective if applied to moist soil in the early evening. For more information, refer to the section *Cutworms*, on page 44.

## Nematode Control

To avoid damage from sugar-beet cyst nematode, do not plant beets following rhubarb, spinach, beets or cruciferous crops. Rotation to non-cruciferous crops for 4–5 years will significantly reduce populations of this nematode. See the section *Nematodes*, on page 45.

## Quality and Storage

Heavy rains following a hot, dry period or extended periods of high temperature will cause poor colour. Rains in the late summer or early fall, when cooler temperatures occur, may increase colour intensity. In general, cool temperatures produce the best flesh colour.

Mature topped beets may be stored for 5–6 months at 0°C and 90%–95% relative humidity.

**How well do table beets respond to micronutrient fertilizers?**
**See the section *Micronutrients*, on page 16.**

## Table 6–10. Disease and Insect Control Recommendations for Table Beets

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Cercospora Leaf Spot** | | | | | | |
| copper sulfate | inorganic | Copper 53 W | 4 kg | 1.6 kg | 1 | |
| **Cutworms** | | | | | | |
| permethrin | pyrethroid | Pounce | 180–390 mL | 73–155 mL | Up to 5-leaf stage | Use higher rates on muck or dry soils. |
| **Aphids** | | | | | | |
| dimethoate | organophosphate | Cygon 480E | 700 mL | 280 mL | 12 | Beet greens only. |
| parathion | organophosphate | Parathion 960 | 225–375 mL | 90–150 mL | 14 | Minimum period for re-entry is 7 days. |
| diazinon[2] | organophosphate | Diazinon 500 EC | 1.1 L | 0.44 L | 14 | |
| | | DZN 600 EW | 915 mL | 370 mL | 14 | |
| malathion[2] | organophosphate | Malathion 25 W | 2.25–5.5 kg | 0.9–2.2 kg | 7 | |
| | | Malathion 500 E | 1.8–2.5 L | 0.7–1.0 L | 3 | |
| **Leaf Miners** | | | | | | |
| dimethoate | organophosphate | Cygon 480-E | 700 mL | 280 mL | 12 | Beet greens only. |
| parathion | organophosphate | Parathion 960 | 225–375 mL | 90–150 mL | 14 | Minimum period for re-entry is 7 days. Also controls webworms. |

[1] Days to Harvest Interval.

[2] Control of aphids with diazinon and malathion has been inconsistent in many areas.

**Visit the vegetable page on the OMAF Web site at www.gov.on.ca/OMAF/english/crops/hort/vegetable.html**

# CARROTS

## Cultivars

Varieties listed in Table 6–11, *Suggested Carrot Cultivars*, below, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

The carrot is a cool-season vegetable. It is best adapted to areas with long, cool growing periods, free from extremes of temperature and moisture. The optimum mean temperature is between 16°C–21°C. High temperatures at the beginning of the growing season are injurious to the young plants. Continuous high temperatures in the latter stages of plant development may reduce yield, retard growth and produce a strong-flavoured, coarse root. Temperatures below 16°C will

**Table 6–11.**
**Suggested Carrot Cultivars**

Note: Cultivars are evaluated mostly on organic soils.

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Baby** | | | |
| Minicor | Seminis | 69 | Baby or 6-inch carrot. Colours up early. |
| Mokum | Bejo Seeds | 54 | Six inches long, sweet flinger carrot. |
| Sweet Bites | Harris-Moran | Mid | Tolerant to alternaria. |
| Sweetheart | Bejo Seeds | 60 | Bunching. |
| **Packaging & Bunching** | | | |
| Annapolis | Seminis | | Slicer potential, nice packaging, strong tops. |
| Big Shot | Seminis | | Tolerant to alternaria. Good potential for early jumbo. |
| Cellobunch | Seminis | | High yield potential, susceptible to green shoulders. |
| Diamond Cut | Seminis | Early-mid | Performs best on mineral soil or shallow muck. |
| HM 03 | Harris-Moran | | Tolerant to bolting. Narrow shoulders, small internal core, strong tops. |
| Ivanhoe | Bejo Seeds | 75 | Cello type, near coreless. |
| Napoli | Bejo Seeds | 55 | Short tops for bunching. |
| Orange Pak | Seminis | | Good storage and length, potential for oversize. |
| Orangette | Crookham | | Smooth, deep colour, good length and tops. |
| Pronto | Seminis | Early | Good potential for early jumbos, performs best on mineral soils. |
| Trigger | Seminis | | Good length, blunt tip, excellent flavour, colour and appearance. Also for slicing. |
| Six Pak and Six Pak II | Harris-Moran | | Resistant to cavity spot and rusty root. Tolerant to blight. |
| **Processing** | | | |
| Bergen | Bejo Seeds | Late | Extra heavy yields, stores well. |
| Carson | Bejo Seeds | | Good interior colour, stores well. |
| Early Gold | Seminis | | Good tops, smooth Danvers type, good for dicing. |
| Fayette | Bejo Seeds | | Tolerant to alternaria. High yields, strong tops, good colour, suitable for dicing. |
| Fontana | Bejo Seeds | 85 | High yields, long storage. For dicing and baby food. Susceptible to leaf blights. |
| Goliath | Seminis | | Smooth Chanenay x Danvers type, good colour. |
| Heritage | Seminis | | Good yields and tops, suitable for dicing. |
| Magno | | | Strong tops, good colour, excellent storage. |
| Nevis | Bejo Seeds | 70 | Tolerant to alternaria. Sweet, cylindrical – slicer. |
| Prodigy | Seminis | | Wider shoulder than Recoleta, can be used on mineral and muck soils. |
| Recoleta | Seminis | | Heavy shoulder, good length, strong tops, suitable for dicing. Performs better on mineral soils. |
| **Cut and Peel Types** | | | |
| Enterprise | Seminis | | Good length, uniform internal colour, strong tops. |
| HM 03 | Harris-Moran | | Tolerant to bolt. Narrow shoulders, uniform internal colour, strong tops. |
| Indiana | Bejo Seeds | 75 | Perfectly cylindrical, deep orange, does well at high plant stands. |
| Newport | Bejo Seeds | 75 | Near coreless. |
| Stylus | Sunseeds | | Narrow shoulders, strong tops, sweet mild flavour. |
| Sugar Snax | Sunseeds | | Long, good flavour, semi-blunt tips, deep orange. |

retard plant growth. Carrots are not tolerant to drought. They require steady and relatively large amounts of moisture for optimum growth. Good yields require regular rainfall or irrigation.

## Soil

Deep, loose, fertile soils that have good water-holding capacity are necessary for the development of long, straight roots. Well-drained sandy loam, peat or muck soils are ideal for carrot production.

## Seeding and Spacing

| | |
|---|---|
| **Time:** | As early as soil and weather conditions permit in the spring up to July 1. Late carrots may "burn off" if they emerge during hot, dry weather. |
| **Rate:** | Fresh market: 2–4.5 kg/ha.<br>Processing: 1–2 kg/ha. |
| **Depth:** | 1.2–2.0 cm. |
| **Row Spacing:** | 55–85 cm depending on planting and harvesting machinery. |
| **Raised Beds:** | Sowing carrots on raised beds (15–20 cm high) improves carrot quality. Beds that are 85 cm (34 in.) wide at the bottom and 50 cm (20 in.) wide on top have yielded good results. Seed carrots in 3 or 4 rows on the centre of the bed at a rate to achieve 120–140 carrots/m for packaging carrots and 26 carrots/m for processing carrots. |

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.

**Mineral soils:** Apply up to 110 kg N/ha. Broadcast 70 kg/ha and all of the required phosphate and potash before planting. Follow up with a side-dress application of 40 kg/ha when the plants are 10 cm tall.

**Muck soils:** Apply up to 60 kg N/ha before planting. Adjust the rate downward if tops have grown too vigorously in previous years.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

### *Magnesium*

Magnesium deficiency may occur on carrots. The usual symptoms are yellowing of older leaves while the veins remain dark green. Consult the section *Magnesium*, on page 13, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### *Micronutrients*

#### Boron

Boron deficiency can cause necrosis in the growing tip or internal breakdown in carrot roots. Boron is often recommended on new muck soils. Use caution when applying boron. This nutrient can build to toxic levels quite quickly. Various sources of boron are available. Consult the section *Boron*, on page 16, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Copper

Copper deficiency may occur on acid peat and muck soils, resulting in carrot roots with poor orange colour. Apply 14–29 kg copper/ha on newly cultivated muck soils. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. Consult the section *Copper*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Disease Management

### *Seed Decay, Damping-Off, Alternaria*

See Table 6–12, *Carrot Seed Treatments*, below, for a list of recommended seed treatments.

**Table 6–12. Carrot Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Apron XL LS | metalaxyl-m | 20–40 mL per 100 kg seed | damping-off and root rot | For use in commercial seed treatment plants only.<br>Export use only |
| Rovral WP | iprodione | | seed-borne alternaria | For imported seed only |

## Table 6–13.
## Carrot Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Leaf Blight** | | | | | | |
| mancozeb | dithiocarbamate | Manzate DF | 2.25 kg | 0.9 kg | 7 | Do not feed treated tops to livestock. |
| | | Dithane DG | 2.25 kg | 0.9 kg | 7 | |
| | | Penncozeb 75 DF | 2.25 kg | 0.9 kg | 7 | |
| zineb | dithiocarbamate | Zineb 80 W | 2.75 kg | 1.1 kg | 7 | |
| chlorothalonil | chloronitrile | Bravo 500 | 2.4–3.2 L | 1.0–1.3 L | 1 | |
| metiram | dithiocarbamate | Polyram 80 DF | 2.25 kg | 0.9 kg | 7 | Do not feed treated tops to livestock. |
| **Sclerotinia Mould** | | | | | | |
| benomyl | benzimadazole | Benlate 50 WP | 0.25–1.1 kg | 0.1–0.4 kg | 15 | Maximum 3 applications/yr. |
| **Cavity Spot** | | | | | | |
| metalaxyl | acylamine | Ridomil 2G | 25 kg | 10 kg | | 215 g/100 m of raised bed.<br>Apply product evenly with seed in the furrow. |

[1] DHI = Days to Harvest Interval

### Aster Yellows

The symptoms of aster yellows on carrots first appear as a reddening of several leaves. Crown growth becomes yellow and brittle, followed by hairy root development. See the section *Aster Leafhopper*, on page 61.

### Leaf Blight

A weather-timed spray program is available in areas where crop monitoring is provided. In this program, fungicide sprays are applied when:

1) Blight appears on 1–2% of the leaf area. This coincides roughly with the time when blight is first detectable.
2) After the first application, a recommended fungicide should be applied at 7–10-day intervals when weather is favourable for blight. The intervals between sprays are extended when the weather is unfavourable for blight. Lack of rainfall or cool nights (minimum temperature less than 15°C) are unfavourable for blight.

If monitoring indicates a need, apply one of the fungicides recommended in Table 6–13, *Carrot Disease Control Recommendations*, above. After the leaves have closed over the rows, spray at 7–10-day intervals.

For further information, consult the OMAF Factsheet, *Management of Carrot Leaf Diseases*, Order No. 00-045.

### Sclerotinia Mould

Rotate with onions, beets or spinach for 2–3 years. Use wider row spacings to encourage good air movement. See Table 6–13, *Carrot Disease Control Recommendations*, above. For effective control, sprays must contact lower leaf petioles and crowns.

### Rusty Root (Pythium Root Dieback)

Follow a 3-year rotation with unrelated crops. Avoid severely infested fields. Sow seed after the soil has warmed up in the spring and use disease-resistant cultivars. Establish uniformly spaced plant populations with precision-seeding equipment and avoid stands of dense foliage.

### Violet Root Rot

This *Rhizoctonia* disease generally shows up in patches in the field and is characterized by soil sticking to the carrot root in a leathery-textured and purplish-coloured mass. Foliar symptoms include wilting tops and dead patches in the field. These symptoms may not always appear until the disease is serious. The fungus causing this disease persists for several years and affects primarily carrots. The best control is to rotate with other crops, such as onions or crucifers. Avoid spreading soil from infested areas to non-infested areas.

### Crown Rot

This disease is caused by a different species of *Rhizoctonia.* Diseased plants appear stunted and wilted in patches in the field. Horizontal, dark-brown lesions develop near the top of the root and may penetrate several millimetres deep. Infected crowns appear dry, rotten and dark brown. There are presently no known control methods other than crop rotation, improving drainage and early harvest. For more information, consult the OMAF Factsheet, *Identification and Management of Carrot Root Diseases*, Order No. 98-001.

## Table 6–14.
## Carrot Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Aster Leafhopper** | | | | | | |
| carbaryl | carbamate | Sevin XLR Plus | 1.25–2.5 L | 0.5–1.0 L | 1 | Use low rate on young plants. |
| parathion | organophosphate | Parathion 960 EC | 375 mL | 150 mL | 14 | Minimum period for re-entry is 7 days. |
| **Carrot Weevil** | | | | | | |
| phosmet | organophosphate | Imidan 50 WP | 2.25 kg | 0.9 kg | 40 | Maximum 2 applications/yr. |
| **Carrot Rust Fly** | | | | | | |
| cypermethrin | pyrethroid | Cymbush 250 EC | 280 mL | 112 mL | 35 | Max 3 applications/yr. |
| diazinon | organophosphate | Diazinon 50 WP | 1.0 kg | 0.4 kg | 10 | |
| | | DZN 600 EW | 915 mL | 366 mL | 10 | |
| parathion | organophosphate | Parathion 960 EC | 375 mL | 150 mL | 14 | Minimum period for re-entry is 7 days. |
| **Cutworms[2]** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 2.4–4.8 L | 0.96–1.9 L | 60 | 24-hr re-entry period.<br>Use high rate on large larvae or dry soils. |
| | | Pyrinex 480 EC | 2.4–4.8 L | 0.96–1.9 L | 60 | 24-hr re-entry period.<br>Use high rate on large larvae or dry soils. |
| permethrin | pyrethriod | Pounce 384 EC | 180–390 mL | 72–156 mL | | Use high rate on muck soils, large larvae or dry soils.<br>Do not disturb soil for 5 days after application. |
| cypermethrin | pyrethriod | Ripcord 400 EC | 175 mL | 70 mL | 21 | Do not disturb soil for 5 days after application. |

[1] DHI = Days to Harvest Interval.

[2] Seedling treatments.

### Cavity Spot

This disease is caused by several *Pythium* species. It rarely reduces yield but can significantly affect quality. Research has shown that cultivars differ in susceptibility. Select cultivars that are least susceptible. (Consult the *Annual Vegetable Cultivar Trials and Research Report* published by the Muck Crops Research Station or with your seed company representatives.) Avoid growing carrots in fields with a history of cavity spot. Crop rotation has not been effective in reducing this disease. See Table 6–13, *Carrot Disease Control Recommendations*, on page 60.

## Insect Management

### Aster Leafhopper

Leafhoppers spread the disease aster yellows. Winter grains are a major source of overwintering leafhoppers. Leafhoppers can be monitored with a sweep net to help determine when and if sprays are required. Without monitoring, there is no way to predict whether scheduled spraying with insecticides will provide any control. It is equally important to control weeds in headlands and ditchbanks, and control leafhoppers on adjacent celery and lettuce.

Spray with one of the pesticides listed in *Table 6–14, Carrot Insect Control Recommendations*, above, when the Aster Yellows Index reaches 50–100, depending upon variety.

**Note:** Rapid killing is obtained using parathion; slower but more lasting control is obtained with carbaryl.

**For information on the Aster Yellows Index system, see the section *Aster Leafhopper*, on page 65.**

### Carrot Weevil

Monitoring for the weevil greatly improves timing of sprays and determines whether they are needed or not. Spray when carrots are in the 2nd–3rd true-leaf stage. Repeat once 10–14 days later. Do not apply more than twice per season or later than 40 days before harvest. Consult the OMAF Factsheet, *Carrot Insects*, Order No. 93-077.

### Carrot Rust Fly

This insect is mainly a problem in the Bradford and Crumlin marsh areas. Growers in other areas should consult a crop specialist before initiating a routine spray program. The first generation of flies is normally present from late May until late June, the second generation from late July until September. Consult the OMAF Factsheet, *Carrot Insects*, Order No. 93-077. If monitoring indicates a need, use one of the pesticides recommended in Table 6–14, *Carrot Insect Control Recommendations*, on page 61.

Carrots seeded after June 1 are rarely attacked by the first generation of the carrot rust fly. Carrots harvested by early September should escape most second generation damage. If possible, avoid growing carrots immediately adjacent to sheltered areas (such as the canal banks of the Holland Marsh). When flies are abundant, sprays may not prevent damage to carrots growing adjacent to sheltered areas.

OMAF Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, provides a comprehensive guide to IPM for carrots.

### *Cutworms*

Cutworms are an occasional problem in carrots. Apply treatments listed in Table 6–14, *Carrot Insect Control Recommendations*, on page 61, at the 2–5-leaf stage if monitoring indicates a problem. Most cutworms hide in the soil during the day and emerge to feed at night. Chemical controls are most effective if applied to moist soil in the early evening. For more information, see the section *Cutworms*, on page 44.

## Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 45.

## Storage

Mature topped carrots can be stored for up to 4–5 months at 0°C and a relative humidity of 90%–98%.

Storage rots occur from infections of the carrot that occurred in the field or through wounds at harvest. Rapid cooling of carrots after harvest is very important for reducing storage rots.

Proper sanitation of the storage and handling equipment is necessary to help reduce storage losses. See the section *Storage Sanitation*, on page 38, for information on sanitation of storages. Also consult the OMAF Factsheet, *Long-Term Storage of Carrots*, Order No. 98-073.

**Spraying pesticides? See Table 1–2, *Safety Supply Companies in Ontario Providing Protective Clothing & Equipment*, on page 5.**

# CELERY

## Cultivars

Varieties listed in Table 6–16, *Suggested Celery Cultivars*, below, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Spacing

| | |
|---|---|
| **Row width:** | 50–55cm (20–22 in.) |
| **In-row spacing:** | 15cm (6 in.) |
| **Rate:** | Approximately 140 g of seed provide enough plants for 1 ha (56 g per acre). |

Plants for the late crop may be started in outdoor seedling beds if water is available for irrigation. The seed may be sown with a seed drill in rows 15–20 cm (6–8 in.) apart, at the rate of 80–110 seeds/m of row so that the stand will not need thinning before transplanting to the field, or seed may be broadcast in a finely prepared bed outdoors at the rate of 15 g/10 $m^2$. The first method provides sturdier plants.

## Soil

Muck soil is ideal for celery production because of its high moisture-holding capacity. Celery may be grown successfully on well-drained mineral soil such as a sandy-loam, but irrigation will be necessary under these conditions.

## Premature Seedstalk Development

The development of flowering shoots instead of normal growth is called "bolting to seed." It is mainly due to exposure of young plants to temperatures below 13°C for 10 days or more.

**Table 6–15.**
**Celery Nitrogen Recommendations**

| Application Method | Recommended Nitrogen (kg/ha) |
|---|---|
| **Mineral soils**[1] | |
| Preplant | 135 |
| Side-dress | 30<br>(up to 2 applications) |
| ***Total*** | ***195*** |
| **Muck soils**[1] | |
| Preplant | 80 |
| Side-dress | 40<br>(up to 2 applications) |
| ***Total*** | ***160*** |

[1] Broadcast and incorporate recommended preplant nitrogen with all of the required phosphate and potash.

The amount of bolting increases as the time of exposure is lengthened. Growers producing plants, especially for the early crop, should maintain greenhouse temperatures of 16°C–21°C. The plants can be hardened, if desired, by withholding water the last 7–10 days before setting in the field. Do not harden-off celery plants by lowering temperatures.

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen application (see Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19). Table 6–15, *Celery Nitrogen Recommendations*, above, shows nitrogen recommendations for mineral and muck soils.

**Table 6–16.**
**Suggested Celery Cultivars**
Note: Cultivars have been evaluated mostly on organic soils.

| Cultivar | Seed Company | Notes |
|---|---|---|
| Florida 683 | | Medium height and dark green foliage, heavy petioles with well-developed heart. |
| Matador | | Tolerant to fusarium yellows. Tall plants with smooth, long petioles, medium green. |
| Peto 285 | Seminis | Tolerant to fusarium yellows. Tall plant, good compactness, smooth petioles. |
| Starlet | | Tolerant to fusarium yellows. Large and somewhat spreading plants. Medium green foliage. |
| Tango $F_1$ | Bejo Seeds | Tolerant to fusarium yellows. Heavy yielder. Extremely smooth stalks. |
| Utah 52-70 | Bejo Seeds | Dark green with sturdy foliage. Long, thick, fleshy stalks. Holds colour in the field. |
| Ventura | Harris-Moran | Tolerant to bolting. Tall plants with long petioles, dark green colour, suitable for early crop. |

## Table 6–17.
## Celery Blight Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| mancozeb | dithiocarbamate | Dithane DG | 2.25 kg | 0.9 kg | 14 | Wash and trim. |
| | | Manzate 200 DF | 2.25–3.25 kg | 0.9–1.3 kg | 14 | Wash and trim. |
| | | Penncozeb 80 WP | 2.25 kg | 0.9 kg | 14 | Wash and trim. |
| metiram | dithiocarbamate | Polyram 80 DF | 2.25 kg | 0.9 kg | 14 | After transplanting only. |
| zineb | dithiocarbamate | Zineb 80 W | 2–3 kg | 0.8–1.2 kg | 14 | |
| copper sulphate | inorganic | Copper 53 W | 3.25–6.5 kg | 1.3–2.6 kg | 1 | Use higher rates as crop increases in size. |
| copper oxychloride | inorganic | Copper Spray 50 W | 4.0 kg | 1.6 kg | 1 | |
| chlorothalonil | chloronitrile | Bravo 500 | 1.6–2.4 L | 0.6–0.96 L | 7 | On a 3–5-day schedule. |
| | | | 2.4–4.0 L | 0.96–1.6 L | 7 | On an 8–10-day schedule. |

[1] Days to Harvest Interval.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.)

### *Secondary Nutrients and Micronutrients*

#### Calcium

Calcium deficiency results in a physiological disorder known as "black heart," in which the celery heart turns black, while the outer leaves are unaffected. If celery is under heat and moisture stress, weekly foliar calcium sprays directed into the heart of the plant may reduce black heart symptoms. See the section *Calcium*, on page 14, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Magnesium

Magnesium deficiency appears as chlorosis between the dark green veins of the older leaves. Some celery cultivars are inefficient in taking up magnesium from the soil. Where soil magnesium levels are low, apply foliar sprays starting when the plants are about one-third grown. See Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Boron

Boron deficiency results in a physiological disease known as "cracked stem" or "cat scratches." See Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Disease Management

### *Seed Treatment*

Buy hot-water-treated seed or sow 3-year-old seed to avoid seed-borne blight fungi. Use seed treated with thiram (dithiocarbamate group) to help prevent damping-off, seedling blight and seed decay. Use 90 g of Thiram 75 WP for every 25 kg of seed.

### *Early Blight (Cercospora), Late Blight (Septoria), Bacterial Blight*

Use a commercial soilless mix or heat-pasteurized soil for growing seedlings in plug trays or flats. Rotate outdoor seedbeds. Use 3-year-old or hot-water-treated seed. Check seedlings for signs of disease and discard any seedlings with symptoms of blight. Do not transplant diseased seedlings into the field.

Start spraying or dusting when seedlings are about 5 cm high and apply one or two applications before transplanting. After transplanting, begin fungicide application when plants are one-third grown or when the first signs of disease are detected. Regular treatments based on careful monitoring will be required throughout the season.

Spray with one of the fungicides recommended in Table 6–17, *Celery Blight Control Recommendations*, above.

### *Aster Yellows*

The symptoms of aster yellows on celery first appear as bright yellowing of several leaves, followed by excessive, brittle, yellow crown growth. Severe twisting and secondary bacterial infections follow. Roguing out infected plants is an effective way to reduce in-field sources of disease.

Aster yellows is transmitted by the aster leafhopper. For control recommendations, see the section *Aster Leafhopper*, below.

### *Fusarium Yellows*

This fungus persists in soil for many years. Fusarium yellows may be introduced in or on transplants and attached soil, in infested soil carried by floodwater, by wind from infested fields nearby, by workers, tools and implements.

Sanitation is important in preventing the spread of this disease. Avoid cultivation practices that can spread infested soil from one area to the rest of the field. Do not return infested celery trimmings to fields after harvest. Practice a 2- to 3-year rotation with onions or lettuce to reduce spore populations in infested fields. Avoid the use of carrots in the rotation scheme.

Varieties tolerant to fusarium yellows listed in Table 6–16, *Suggested Celery Cultivars*, on page 63, will withstand soils with moderate levels of the fungus. Note that high fungal populations, excessive heat and drought stress may diminish this tolerance. For more details, consult with your seed company representative.

### *Pink Rot (Sclerotinia White Mould)*

Pink rot is an occasional problem during wet seasons. A white-pinkish mould develops on lower petioles and may be followed by rapid secondary rots. Wider row spacings will facilitate airflow and reduce the chance of infection. Where infection has occurred, rotate to onions or another non-susceptible crop.

### *Cucumber Mosaic Virus*

Aphids vector the mosaic virus by picking up the disease from infected weeds. Control weeds bordering the crop area. Rogue out plants if mosaic infection is noticed early in the season. Keeping aphids under control may reduce the spread of the virus, however, it will not entirely prevent it.

## Insect Management

### *Aster Leafhopper*

Aster leafhoppers spread the aster yellows virus.

Control weeds in headlands and ditchbanks and control leafhoppers on adjacent carrots and lettuce. To help slow down the rate of resistance, alternate the use of insecticides from the various chemical groups.

To use the Aster Yellows Index (AYI), monitor aster leafhoppers with a sweep net. Multiply the number of aster leafhoppers captured in 100 sweeps by the percentage of leafhoppers carrying aster yellows in your area (4%–5% is the currently recommended percentage infectivity in Ontario). Use this formula:

$$\frac{\text{\# leafhoppers}}{\text{100 sweeps}} \times \text{\% infectivity} = \text{AYI}$$

Treat when the AYI equals 20–25 for head lettuce, 30–35 for celery and romaine, and 50–100 for carrots. For more details, consult the OMAF Factsheet, *The Aster Leafhopper and Aster Yellows*, Order No. 98-057.

Without monitoring, there is no way to predict whether scheduled spraying with insecticides will provide any control. If monitoring indicates a need, spray with one of the insecticides recommended in Table 6–18, *Celery Insect Control Recommendations*, on page 66.

### *Carrot Weevil*

Carrot weevil can seriously damage celery roots and the crown, causing stunting and plant collapse. For monitoring information, see the section *Carrot Weevil*, on page 61. Chemical control options are listed in Table 6–18, *Celery Insect Control Recommendations*, on page 66.

### *Tarnished Plant Bug*

Monitoring for the adult tarnished plant bug (TPB) and the nymphs will help improve control. Check at least 50–100 plants randomly in the field. Adults will fly in short, quick bursts, and the green nymphs will run quickly from the plants, making monitoring difficult. Thresholds are based on growth stage and numbers of TPB per plant.

When threshold levels of 0.1–0.2 TPB per plant are reached, apply the insecticides recommended in Table 6–18, *Celery Insect Control Recommendations*, on page 66. For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

### *Aphids*

Monitoring can help confirm when and if sprays are required. Check 50–100 plants and record the number of plants infested with aphids. Note also the average number of aphids per plant. If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–18, *Celery Insect Control Recommendations*, on page 66. Note that the sunflower aphid and the green peach aphid may have developed resistance to insecticides in some areas.

## Table 6–18.
## Celery Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Aster Leafhopper** | | | | | | |
| cypermethrin | pyrethroid | Cymbush 250 EC | 140 mL | 56 mL | 7 | Maximum 3 applications per season. |
| parathion | organophosphate | Parathion 960 EC | 225–375 mL | 90–150 mL | 14 | Maximum 2 applications per season. Minimum period for re-entry is 7 days. |
| malathion | organophosphate | Malathion 500 E | 2.25 L | 0.9 L | 7 | |
| carbaryl | carbamate | Sevin XLR Plus | 1.25–2.5 L | 0.5–1 L | 5 | |
| **Carrot Weevil** | | | | | | |
| phosmet | organophosphate | Imidan 50 WP | 2.25 kg | 0.9 kg | 40 | Maximum 2 applications per season. |
| **Tarnished Plant Bugs** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.75 kg | 0.7 kg | 14 | Trim the celery of all outer leaves. |
| | | Thiodan 4 EC | 2.0 L | 0.8 L | 14 | |
| | | Endosulfan 50W | 1.75 kg | 0.7 kg | 14 | |
| acephate | organophosphate | Orthene 75 SP | 0.75–1.1 kg | 0.3–0.44 kg | 21 | Maximum 4 applications/yr. |
| **Aphids** | | | | | | |
| naled | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.75 kg | 0.7 kg | 14 | Trim the celery of all outer leaves. |
| | | Thiodan 4 EC | 2.0 L | 0.8 L | 14 | |
| | | Endosulfan 50W | 1.75 kg | 0.7 kg | 14 | |
| acephate | organophosphate | Orthene 75 SP | 0.75–1.1 kg | 0.3–0.44 kg | 21 | Green peach aphid only. |
| pirimicarb | carbamate | Pirimor 50 DF | 300–500 g | 120–200 g | 10 | Maximum 4 applications/yr. |
| **Cabbage Looper** | | | | | | |
| Bacillus thuringiensis | microbial | Thuricide HPC | 2.0–4.25 L | 0.8–1.7 L | 0 | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.75 kg | 0.7 kg | 14 | Trim the celery of all outer leaves. |
| | | Thiodan 4 EC | 2.0 L | 0.8 L | 14 | |
| | | Endosulfan 50W | 1.75 kg | 0.7 kg | 14 | |
| naled | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | |
| **Cutworms**[2] | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.2–2.4 L | 0.48–0.96 L | 70 | 24-hr re-entry period. Use high rate on large larvae or dry soils. |
| | | Pyrinex 480 EC | 1.2–2.4 L | 0.48–0.96 L | 70 | 24-hr re-entry period. Use high rate on large larvae or dry soils. |

[1] DHI = Days to Harvest Interval.

[2] Seedling treatments.

Consult the OMAF Factsheet, *Aphids Infesting Lettuce and Celery in Ontario*, Order No. 00-053.

### Cabbage Looper

This is a rare problem in Ontario celery, however, it can cause sporadic damage. Check plants randomly in the field and record the percentage of plants infested. Five per cent infestation is suggested as a threshold guideline.

### Leaf Miners

There are four main species of leaf miners that may attack vegetables and ornamentals in North America, including serpentine, vegetable, pea and chrysanthemum. The pea leaf miner has been found in the Holland Marsh area of Ontario. The pea leaf miner attacks celery and is known to have a wide host range including celery, onions, Asian vegetables, lettuce, cucumbers, snow peas and other leafy vegetables.

Severe damage to leaves can reduce the photosynthetic ability of the plants and impede water movement, leading to leaf-drop. Pea leaf miner damage may reduce the marketability of fresh market celery. Damage from the other three species to celery is minimal.

Consult the OMAF Factsheet, *Leaf Miners Attacking Field Vegetables and Greenhouse Crops*, Order No. 00-039. No thresholds for leaf miners on celery or any of the other crops have been established.

### *Cutworms*

Cutworms are an occasional pest of celery both early in the season and sometimes later in the season, when climbing cutworm species seriously damage celery petioles. Chemical control measures are more effective if applied in the late afternoon or early evening. Small cutworms are easier to control than large ones. See Table 6–18, *Celery Insect Control Recommendations*, on page 66.

The OMAF Publication *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, Order No. 700, provides a comprehensive guide to IPM for celery.

## Nematode Control

For nematode control recommendations, see the section *Nematode Control*, on page 45.

## Storage

Do not store celery that has been badly damaged by frost, disease or handling. A relative humidity of 95%–98% and a temperature of 0°C are ideal. Celery should be stored in a room that is free from odours, because the plant absorbs foreign flavours. Field heat should be removed by hydro-cooling or vacuum-cooling, before placing in large storage rooms.

### Caution

Some individuals may be sensitive to the natural chemicals found in celery. These substances increase if celery is diseased. Using rubber gloves when handling celery and leg protection when walking in the field will prevent the development of skin rashes.

**Looking for IPM monitoring supplies?**
**See Table 5–1, *Monitoring Equipment Suppliers*, on page 42.**

# COLE CROPS

## BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER, HORSERADISH, KALE, KOHLRABI

### Cultivars

The cole crop varieties listed in Table 6–21, *Suggested Cole Crop Cultivars*, on page 69, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

### Seeding and Spacing

About 300–350 g of seed will provide enough transplants for 1 hectare at standard spacing (120–140 g/ac). See Table 6–19, *Seeding and Spacing of Cole Crop Vegetables*, below, for recommendations. Note that the newer, compact hybrids may be grown at closer spacings than the older, traditional cultivars.

With Brussels sprouts grown for once-over harvesting and especially where smaller sprouts are required for freezing, the uniformity of the sprouts up the stem can be improved by growing the plants on a closer square spacing, e.g., 60 x 60 cm, or even as close as 53 x 53 cm.

For broccoli crops that will be harvested during the hot, humid weather of late August to early September, increase plant spacing to the wider end of the recommended range.

### Stand Establishment

Direct seeding in the field is possible for late summer and fall crops of cabbage, cauliflower, broccoli and Brussels sprouts. However, this practice is not widely used in Ontario.

The emphasis is now on once-over harvesting of some crops and reduced frequency of harvesting for others. This demands concentration of crop maturity. Consider establishing transplants from plug trays as a prime method of promoting crop and maturity uniformity instead of from open-field seedbeds. Despite the higher initial cost of plug plants, considerable savings can be realized through higher recovery of plants per unit of seed, reduced costs of pulling plants and more rapid transplanting into the field. Plug-raised plants also establish more quickly and provide a more uniform and more vigorous population than bare-root transplants.

**Table 6–19.**
**Seeding and Spacing of Cole Crop Vegetables**

| Vegetable | Row Spacing | In-Row Spacing |
|---|---|---|
| Cabbage (early), broccoli | 60–75 cm<br>(24–30 in.) | 30–45 cm<br>(12–17 in.) |
| Cabbage (late), cauliflower, Brussels sprouts | 75–90 cm<br>(30–35 in.) | 45–60 cm<br>(17–24 in.) |
| Horseradish | 75–90 cm<br>(30–35 in.) | 40–60 cm<br>(16–24 in.) |
| Kale | 70–80 cm<br>(28–32 in.) | thinned to about 30 cm (12 in.) apart |
| Kohlrabi | 70–80 cm<br>(28–32 in.) | thinned to about 10 cm (4 in.) apart |

For more information, see the section *Vegetable Transplants*, on page 151.

For direct seeding to be successful, soil management practices to reduce uneven plant stands and soil crusting are essential. Weed control can be more difficult in direct-seeding because of a lack of effective registered herbicides.

### Fertility

#### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.) Apply nitrogen according to the recommendations in Table 6–20, *Cole Crop Nitrogen Recommendations*, below.

**Table 6–20.**
**Cole Crop Nitrogen Recommendations**

| | Broccoli, Cauliflower, Brussels Sprouts | Cabbage | Horseradish, Kale, Kohlrabi |
|---|---|---|---|
| **Mineral Soils**[1] | | | |
| Preplant[2] | 100 kg/ha | 130 kg/ha | 80 kg/ha |
| Side-dress (3 wk after field setting) | 30 kg/ha | 40 kg/ha | 30 kg/ha |
| **Total Recommended** | **130 kg/ha** | **170 kg/ha** | **110 kg/ha** |
| **Muck Soils** | | | |
| Preplant[2] | 70 kg/ha | 100 kg/ha | 70 kg/ha |
| 1st side-dress | 30 kg/ha | 30 kg/ha | 30 kg/ha |
| 2nd side-dress | 30 kg/ha | 30 kg/ha | 30 kg/ha |
| **Total Recommended** | **130 kg/ha** | **160 kg/ha** | **130 kg/ha** |

[1] If rainfall is excessive, an additional 40 kg of nitrogen/ha may be side-dressed on sandy soils.

[2] Broadcast and incorporate recommended preplant nitrogen with all the required phosphate and potash.

## Table 6–21.
## Suggested Cole Crop Cultivars

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Broccoli** | | | |
| Durango | Bejo Seeds | 70 | Resistant to fusarium yellows. For "crown" use. |
| Fiesta | Bejo Seeds | 72 | Resistant to fusarium yellows. |
| Regal | Harris-Moran | 80–100 | Semi-dome head. |
| **Brussels Sprouts** | | | |
| Diablo | Bejo Seeds | 125 | Resistant to fusarium yellows. Fresh market and processing. |
| Harley | Bejo Seeds | 115 | Very solid sprout. |
| **Cabbage** | | | |
| Charmed Dynasty | Seminis | Early | |
| Green Express | | Early | Resistant to fusarium yellows. |
| Atlantis | Seminis | 70–85 | Tolerant to fusarium yellows and bolt. High-quality, round dense heads with short cores. |
| Balaton | | Mid | |
| Blue Thunder | Harris-Moran | Mid | Tolerant to fusarium yellows. Upright, round. |
| Bronco | Bejo Seeds | 78 | Resistant to fusarium yellows. Tolerant to thrips and tipburn. |
| Genesee | Seminis | Mid | |
| Platinum Dynasty | Seminis | Mid | |
| Rhinda | Seminis | Mid | |
| Silver Dynasty | Seminis | Mid | Resistant to fusarium yellows. Tolerant to black rot. Widely adapted to major cabbage-growing areas. |
| **Storage Type** | | | |
| Huron | Seminis | Late | Resistant to fusarium yellows. |
| Missouri | Seminis | Late | |
| Saratoga | Bejo Seeds | 105 | Resistant to fusarium yellows. Tolerant to thrips. Very long storage. |
| **Red** | | | |
| Rona | Seminis | 120 | |
| Zelox | Seminis | | For red processing. |
| **Savoy** | | | |
| HMX 0220 | Harris-Moran | 85–90 | 3–6 lb. |
| **Cauliflower** | | | |
| Baldo | Seminis | Early | |
| Minuteman | Seminis | Early | |
| Pathfinder | Seminis | Early | Good self wrap and matures fast. Plant for first cut in June or early July. |
| Amazing | Bejo Seeds | 75 | Large and dense. |
| Apex | Harris-Moran | Mid | Self-wrapping. |
| Cassius | Bejo Seeds | | Trial Freemont type. |
| Freedom | Seminis | Mid | |
| Fremont | Seminis | Mid | Stands up to heat stress. |
| Vinson | Seminis | Mid | |
| Wentworth | | Mid | |
| Cumberland | Seminis | Late | |
| Lateman | Bejo Seeds | 90 | Performs well under tough conditions. |
| Minuteman | Seminis | Late | Very uniform and suitable for processing. Grows well in cool conditions. Appropriate for fall harvest. |
| Wentworth | Seminis | Late | |
| **Horseradish — Refer to current seed catalogues for cultivars suitable to your area.** | | | |
| **Kale** | | | |
| Redbor | Bejo Seeds | 55 | Dark red leaf colour. |
| Winterbor | Bejo Seeds | 50–55 | Resistant to fusarium yellows. Overwinters well. |
| **Kohlrabi** | | | |
| Kolibri | Bejo Seeds | 50 | Purple fresh market. |
| Kongo | Bejo Seeds | 48 | White short foliage. |
| Kossak | Bejo Seeds | 85 | White 8 in. for processing. |

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

### Starter Solution

If no insecticide is being added to the planting water, use a starter solution high in nitrogen such as 20-20-20 at 1 kg/200 L and apply 0.2–0.3 L per plant. Under high-temperature conditions or in dry sandy soils, use only 0.5 kg of 20-20-20/200 L of water. This will reduce the risk of crop injury under these growing conditions.

### Micronutrients

#### Brown Heart or Hollow Stem (Boron Deficiency)

Boron deficiency has been shown to cause hollow stem in broccoli, but not all hollow stem is caused by boron deficiency. See the section *Boron* and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Whiptail (Molybdenum Deficiency)

This deficiency causes whiptail in cauliflower, broccoli and Brussels sprouts. Consult the section *Molybdenum*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### Cauliflower Blanching

A perfect head of cauliflower is essentially pure white or pale cream. Heads exposed to sunlight develop an objectionable yellow pigment. Small inner leaves curve over the head and cover it while it is small. As the head enlarges, these leaves begin to lift, and some other means of covering is necessary to exclude sunlight. The usual method is to tie the outer leaves over the heads when the heads are 8–10 cm (3–4 in.) in diameter.

In hot weather, blanching may take only 3–4 days, but in cool weather, when growth is slow, 8–12 days or more may be required. Mark heads tied at different times with different colours of twine or rubber bands to indicate probable maturity date and make harvesting easier. Some cultivars are better able than others to give natural curd protection by the inner wrapper leaves, without tying.

### Broccoli Harvesting

Cut heads when the clusters are green and compact. Open and yellow clusters are undesirable. Terminal broccoli heads are cut with 15–20 cm (6–8 in.) of stem. Lateral shoots from the axils of the leaves develop into marketable heads soon after the terminal head is removed. These laterals produce a continuous crop for several weeks.

Some of the new hybrids produce very few laterals. Continuity of production with these cultivars may be obtained by successive plantings in the spring and summer.

### Brussels Sprouts Harvesting

Harvesting should begin when the sprouts are firm and well formed. When hand picking, break off the leaf below the sprout and remove the sprout. The upper sprouts continue to form and enlarge as the lower ones are harvested. In an early crop, the lower sprouts should be picked as soon as they mature; otherwise, they will open up, become soft, turn yellow and eventually rot.

For once-over harvest, topping the plants will prevent any further extension of growth and encourage the maturity of the small sprouts at the top of the stem. Topping is normally done when the sprouts at the bottom of the stem are about 12–20 mm (0.5–0.8 in.) in diameter. A full stem of uniform, marketable-sized sprouts will develop about 4 weeks later. Do not de-leaf plants more than 1 day before harvest.

## Disease Management

### Seed Decay, Damping-Off, Wirestem, Black Rot, Blackleg

Hot-water treatment (see the section *Hot-Water Treatment*, on page 152) is most important to help prevent black rot, blackleg and bacterial leaf spot. See Table 6–22, *Cole Crop Seed Treatments*, below, for a list of recommended chemical seed treatments.

**Table 6–22.**
**Cole Crop Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Streptomycin 17 | streptomycin sulfate | 20 g in 10 L of water treats 1 kg of seed | bacterial black rot | Not for use on kale, horseradish or kohlrabi. May be toxic to some cultivars – refer to label. |
| Thiram 75 WP | thiram | 90 g per 25 kg of seed | damping-off, seedling blight, seed decay | Not for use on kale, horseradish or kohlrabi. |
| Vitavax RS | carbathiin-thiram-lindane | 22.5 mL per 1 kg of seed | flea beetles, damping-off, root rots | Do not store treated seed.<br>Not for use on kale, horseradish or kohlrabi. |

### Table 6–23.
### Cole Crop Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Downy Mildew, Black Leaf Spot** | | | | | | |
| zineb | dithiocarbamate | Zineb 80 W | 2.25–3.25 kg | 0.9–1.3 kg | 7 | Not on horseradish, kale or kohlrabi. |
| copper sulphate[2] | inorganic | Copper 53 W[2] | 4.0 kg | 1.6 kg | 1 | Not on horseradish, kale or kohlrabi. |
| chlorothalonil | chloronitrile | Bravo 500F | 2.5–4.8 L | 1–1.9 kg | 7 | Not on horseradish, kale or kohlrabi. |
| fosetyl-al | phosphonate | Aliette 80 WDG | 2.25–3.12 kg | 0.9–1.25 kg | 7 | Broccoli only. Max 5 applications/yr. 12-hr re-entry period. |
| **Black Leaf Spot Only** | | | | | | |
| iprodione[3] | dicarboximide | Rovral WP[3] | 3 kg | 1.2 kg | 7 | Storage cabbage. |
| | | | | | 5 | Cauliflower. |
| **Clubroot (transplant treatment)[4]** | | | | | | |
| quintozene | chlorophenyl | Quintozene 75 WP | 250 g per 100 L water<br>Apply at least 200 mL per plant. | | | Provide good agitation during application. |

[1] Days to Harvest Interval.
[2] Fixed copper may be phytotoxic to cauliflower.
[3] Apply Rovral on storage cabbage 7–14 days prior to harvest and on cauliflower 1–2 days prior to tying.
[4] Chemical control of clubroot is inconsistent.

Where possible, follow a 3-year rotation with unrelated crops. Field seedbeds should not be located downhill from where cabbage and related crops have been grown or where residues of these crops will be blown by wind or spilled from passing trucks, etc. Avoid working in wet fields.

**Note:** Some cultivars are more susceptible to black rot than others. Check the seed packet to be sure that the incidence of black rot is not greater than 1 in 30,000 and check with seed company representatives about cultivars tolerant to black rot.

### Fusarium Yellows, Fusarium Wilt

Use resistant cultivars (consult seed catalogues). If susceptible cultivars are grown, produce transplants in steamed or fumigated soil, and transplant to fields where yellows has not previously appeared.

### Clubroot

This fungus causes swollen roots and wilting plants (Consult the OMAF Factsheet, *Fungal Diseases of Cruciferous Crops*, Order No. 85-043). The resting spores of the fungus persist in soil for at least 7 years. The organism can move in the soil water, spreading infection within and between fields. Avoid wet, poorly drained soils. Grow seedlings or transplants in soil free of disease.

The most reliable control measure is liming with finely ground lime to a pH of 7.2. Where soil pH is above 7.0, gypsum is a more soluble source of calcium. For more information, see the section *Soil pH and Liming*, on page 11. Do not use hydrated lime on seedbeds.

See Table 6–23, *Cole Crop Disease Control Recommendations*, above.

### Downy Mildew

Downy mildew may appear in the seedbed or late in the season. In cool, wet weather conditions, preventive spraying is recommended. The fungicides listed in Table 6–23, *Cole Crop Disease Control Recommendations*, above, will only prevent new infections and not eradicate established lesions.

### Black Leaf Spot (Alternaria)

This disease may be damaging in warm, wet seasons. Spray with one of the materials listed in Table 6–23, *Cole Crop Disease Control Recommendations*, above.

**Note:** It is important to control downy mildew and black leaf spot on storage cabbage. Prevent the development of resistance by rotating between recommended products.

## Insect Management

**Caution**

- Do not use emulsifiable formulations in the planting water.
- Do not add fertilizer to planting water containing an insecticide unless recommended by the manufacturer or until experience has proven the mixture to be safe.

### Root Maggot

Root maggot management is primarily preventative, however, high soil temperatures, low soil moisture, natu-

## Table 6–24.
## Root Maggot Control Recommendations for Cole Crops

| Common Name | Group | Trade Name | Rate | DHI[1] | Notes |
|---|---|---|---|---|---|
| **Planting-Water Treatment** | | | | | |
| azinphos-methyl | organophosphate | APM 50 W | 1 kg in 1,000 L of water<br>Apply 115–170 mL/plant in transplant water. | 21 | For cabbage, cauliflower, broccoli, Brussels sprouts only. Repeat in 2–3 wk.<br>48-hr re-entry period. |
| | | Guthion Solupak 50 WP | | | |
| | | Sniper 240 E | 2 L/1,000 L of water<br>Apply 115–170 mL/plant in transplant water. | | |
| chlorpyrifos | organophosphate | Lorsban 50 W | 65 g/200 L of water<br>Apply 200 mL/plant. | 32 | For cabbage only. Do not use with starter fertilizers or lindane (Vitavax)-treated seed. |
| | | Pyrifos 50 W | | | |
| **Treatment After Planting** | | | | | |
| azinphos-methyl | organophosphate | APM 50 W | 1 kg in 1,000 L of water<br>Apply 115–170 mL/plant. | 21 | For cabbage, cauliflower, broccoli, Brussels sprouts only. 48-hr re-entry period. |
| | | Guthion Solupak 50 WP | | | |
| | | Sniper 240 E | 2 L/1,000 L of water<br>Apply 115–170 mL/plant. | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 210 mL/130 L of water per 1,000-m row | 32 | For cabbage, cauliflower, broccoli, Brussels sprouts only. Apply in a 10-cm band on each side of the plant 3 days after transplanting. Maximum 2 applications per year (3 on Brussels sprouts.) |
| | | Pyrinex 480 EC | | | |
| **Direct-Seeded Crops** | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 210 mL/1,000-m row | 32 | For cabbage, cauliflower, broccoli only. Apply 10 cm on each side of the plant 7–10 days after seeding. |
| | | Pyrinex 480 EC | | | |
| | | Lorsban 15 G | 0.6–1.0 kg/1,000-m row | | For cabbage, cauliflower, broccoli, Brussels sprouts only. |
| | | Pyrifos 15 G | | | |

[1] Days to Harvest Interval.

ral predators, crop rotation and field sanitation are also important. Later plantings are less likely to require protection. See Table 6–24, *Root Maggot Control Recommendations for Cole Crops*, on page 72.

### *Flea Beetles*

Monitoring greatly improves flea beetle control. Up to the 6th-leaf stage, the tolerance for flea beetles is 1 per plant. After the 6th-leaf stage, flea beetles are less of a concern unless you are selling the tops of radishes or Asian cruciferous greens. Chinese/Indian mustard (*Brassica juncea* var. *crispifolia*) can act as an effective trap crop also. See Table 6–25, *Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations for Cole Crops*, on page 73.

### *Thrips*

Thrips damage can occur on all cole crops. However, cabbage appears to be the most susceptible. Evidence also suggests that late plantings suffer less damage than earlier ones. Spraying for thrips should start once cupping of cabbage occurs. Thrips can also damage the curds of cauliflower, leaving them unmarketable. See Table 6–25, *Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations for Cole Crops*, on page 73.

Some varieties of cabbage are more susceptible to thrips, and these may benefit the most from sprays. Ratings on thrips damage are obtained each year through storage cabbage variety trials. Over-mature cabbage is a prime target for thrips. Harvesting cabbage at the proper maturity will help reduce thrips loss.

For more information, consult the OMAF Factsheet, *Thrips on Onions and Cabbage*, Order No. 99-027.

### *Cutworms*

Cutworms are a very occasional problem in cole crops. Apply controls listed in Table 6–25, *Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations for Cole Crops*, on page 73, only when monitoring indicates a problem. Most cutworms hide in the soil during the day and emerge to feed at night. Chemical controls are most effective if applied to moist soil in the early evening. See the section *Cutworms*, on page 44, for cutworm management recommendations.

## Table 6–25.
## Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations for Cole Crops

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Flea Beetles** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 1.5–2.0 L | 0.6–0.8 L | 7 | Not on horseradish, kale, kohlrabi. |
| | | Thiodan 50 WP | 1–1.75 kg | 0.4–0.7 kg | 7 | Not on horseradish, kale, kohlrabi. |
| carbaryl | carbamate | Sevin XLR plus | 1.25–2.5 L | 0.5–1 L | 3 | For cabbage and cauliflower. |
| | | | | | 5 | For broccoli, kohlrabi and Brussels sprouts. |
| | | | | | 7 | For horseradish. |
| | | | | | 21 | For kale. |
| cypermethrin[2] | pyrethroid | Ripcord 400 EC[2] | 87.5–125 mL | 35–50 mL | 3 | Not on horseradish, kale, kohlrabi.<br>Maximum 3 applications per year. |
| deltamethrin | pyrethroid | Decis 5 EC | 150–200 mL | 60–80 mL | 3 | Use on cabbage only. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 42 mL | 17 mL | 1 | For cabbage. 24-hr re-entry period.<br>Maximum 3 applications per year. |
| | | | | | 3 | For broccoli, cauliflower, Brussels sprouts.<br>24-hr re-entry period.<br>Maximum 3 applications per year. |
| permethrin | pyrethroid | Pounce 384 EC | 90–180 mL | 36–72 mL | 2 | For horseradish. |
| | | | | | 3 | For cabbage, cauliflower, Brussels sprouts. |
| | | | | | 7 | For broccoli. |
| **Thrips** | | | | | | |
| cypermethrin[2] | pyrethroid | Ripcord 400 EC[2] | 87.5–125 mL | 35–50 mL | 3 | For cabbage, cauliflower, broccoli, Brussels sprouts only. |
| | | Cymbush 250 EC[2] | 200 mL | 80 mL | 3 | For cabbage, cauliflower, broccoli, Brussels sprouts only.<br>Use Agral 90 at 300 mL/1,000 L spray. |
| parathion | organophosphate | Parathion 960 E | 375–590 mL | 150–235 mL | 14 | Not on kohlrabi, horseradish.<br>7-day re-entry period. |
| **Cutworms** | | | | | | |
| permethrin | pyrethroid | Pounce 384 EC | 180–390 mL | 72–155 mL | 3 | Brussels sprouts, cabbage, cauliflower.<br>Use high rate on dry soils or large larvae. |
| | | | | | 7 | Broccoli.<br>Use high rate on dry soils or large larvae. |
| cypermethrin[2] | pyrethroid | Ripcord 400 EC[2] | 175 mL | 70 mL | 14 | Do not disturb soil for 5 days after application. |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.2–2.4 L | 0.5–1 L | 32 | For cabbage, cauliflower, broccoli, Brussels sprout only.<br>Apply at 2–5-leaf stage |
| | | Pyrinex 480 EC | 1.2–2.4 L | 0.5–1 L | 32 | For cabbage, cauliflower, broccoli, Brussels sprout only.<br>Apply at 2–5-leaf stage |
| **Slugs** | | | | | | |
| methomyl | carbamate | Lannate SP | 775 g | 310 g | 30 | For Brussels sprouts only.<br>24-hr re-entry period. |

[1] Days to Harvest Interval.

[2] Do not use on muck soils.

### Slugs

For slug control recommendations, see Table 6–25, *Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations for Cole Crops*, on page 73.

### Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar

Infestations of cabbageworm and diamondback moth caterpillar may begin early in the season. Cabbage loopers usually appear after mid-July.

Insecticides are less effective against large larvae. Begin application of insecticides when young larvae are found and continue at 5- to 10-day intervals, or as necessary for adequate protection of the crop. Scouting is an excellent way to assess the population of cole-crop caterpillars.

Table 6–26, *Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops*, on page 75, lists recommended pest control products by group. To limit the development of resistance, insecticides from one of the groups listed must be used alternately with one from another group. Use pyrethroid insecticides during the fall, as they are more effective under cool conditions. Consult the OMAF Factsheet, *Caterpillar Pests of Cruciferous Crops*, Order No. 99-035.

**Note:** Many of these insecticides are not consistently effective against cabbage looper and diamondback moth larvae. The carbamates, azinphos-methyl and naled have been inconsistent in some areas. Spray small areas first to check if the product is working in your area. Also note that the repeated use of synthetic pyrethroids in cole crop fields may lead to aphid resurgence.

### Aphids

Good coverage (bottom of leaves) is essential for aphid control. Drop nozzles and increased water volumes are necessary. If monitoring indicates a need, spray with one of the pest control products listed in Table 6–27, *Aphid Control Recommendations for Cole Crops*, on page 76.

### Swede Midge

The Swede midge is a new pest to Ontario. Swede midge damage can occur on all cole crops. Clusters of eggs are laid on the youngest part of the plant, both on the flower buds and the central leaves. The developing insect larvae, if present, are tiny and difficult to detect.

Damage symptoms and severity depend upon the number of larvae present and the growth stage of the plant attacked. Damaged seedlings often appear twisted and have a noticeable brown scar at the growing point. If damage occurs before the plant reaches the button stage, then no heads will be produced. If damage occurs once head formation has already begun, the resulting heads will be twisted and distorted. Brown scars are typically found within the head and along leaf stalks, making the head unmarketable. Feeding by larvae can also promote the entry of pathogenic bacteria and fungi, resulting in rotting. These symptoms are often mistaken for symptoms of poor seed quality, heat stress or nutrient deficiencies.

### Tarnished Plant Bug

Both the adults and nymphs of this insect can damage the heads of broccoli and cauliflower. Brown beading of broccoli and brown streaking of cauliflower may be caused by tarnished plant bug (TPB) feeding.

For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

### Nematode Control

See the section *Nematodes*, on page 45, for nematode control recommendations.

## Physiological Disorders

### Cabbage Splitting

Well-developed cabbage heads may split or burst if rain or a heavy irrigation follows a dry spell. Splitting results from rapid new growth due to the increased moisture. Timely irrigation may prevent splitting by helping to maintain steady plant growth. Deep cultivation may also break up roots, preventing excessive growth.

### Bolting

Low temperatures early in the growing season may cause premature seedstalk development. The earlier the seed is sown, the greater the bolting tendency. Bolting may also be caused by extreme changes in temperature, poor soil conditions or low nutrient levels. Some cultivars, particularly early ones, are more susceptible to bolting.

### Tipburn of Cauliflower and Cabbage

Tipburn can occasionally cause severe economic losses in cabbage and cauliflower. Tipburn is a breakdown of plant tissue near the centre of the head in cabbage and on the inner wrapper leaves of cauliflower. It is a physiological disorder associated with an inadequate supply of calcium in the affected leaf margins causing a collapse of the tissue and death of the cells.

High temperatures and fluctuating soil moisture conditions hinder the movement of calcium into the leaves, leading to tipburn.

## Table 6–26.
## Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations for Cole Crops

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| Bacillus thuringiensis | microbial | Dipel 2XDF | 55–550 g | 22–220 g | 0 | 275–550 g for loopers. |
| | | Thuricide HPC | 2.0–4.25 L | 0.8–1.7 L | 0 | Use higher rates for looper control, heavy infestations or when foliage is dense. |
| | | Bioprotec CAF | 1.4–2.8 L | 0.5–1.1 L | 0 | |
| permethrin | pyrethroid | Pounce 384 EC | 90–180 mL | 36–72 mL | 3 | Cabbage, cauliflower, Brussels sprouts. |
| | | | | | 7 | Broccoli. |
| deltamethrin | pyrethroid | Decis 5.0 EC | 150–200 mL | 60–80 mL | 1 | Brussels sprouts only. |
| | | | | | 3 | Cabbage, cauliflower, broccoli only. |
| cypermethrin[2] | pyrethroid | Ripcord 400 EC[2] | 87.5–125 mL | 35–50 mL | 3 | Cabbage, cauliflower, broccoli, Brussels sprouts only. |
| | | Cymbush 250 EC[2] | 140 mL | 56 mL | 3 | Cabbage, cauliflower, broccoli, Brussels sprouts only. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 42 mL | 17 mL | 1 | Cabbage. Imported cabbageworm and diamondback moth larvae. |
| | | | | | 3 | Broccoli, cauliflower, Brussels sprouts. Imported cabbageworm and diamondback moth larvae. |
| | | | 83 mL | 33 mL | 1 | Cabbage. Cabbage looper. |
| | | | | | 3 | Broccoli, cauliflower, Brussels sprouts. Cabbage looper. |
| methomyl[2] | carbamate | Lannate SP[2] | 270–540 g | 108–216 g | 1 | Cabbage. 24-hr re-entry period. |
| | | | | | 7 | Cauliflower, broccoli, Brussels sprouts. |
| carbaryl | carbamate | Sevin XLR Plus | 2.5–5.25 L | 1–2.1 L | 3 | Cabbage and cauliflower. |
| | | | | | 5 | Broccoli and Brussels sprouts. |
| | | | | | 7 | Horseradish. |
| | | | | | 21 | Kale. |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1–1.75 kg | 0.4–0.7 kg | 7 | Not on kale, kohlrabi, horseradish. Use high rate on loopers. |
| | | Thionex 400 EC | 1.5–2.0 L | 0.6–0.8 L | 7 | Not on kale, kohlrabi, horseradish. Use high rate on loopers. |
| naled | organophosphate | Dibrom EC | 1.1–2.2 L | 0.4–0.9 L | 4 | 2.2 L rate for loopers only. Not on kohlrabi, horseradish. |
| methamidophos[3] | organophosphate | Monitor 480[3] | 1.1–2.25 L | 0.4–0.9 L | 7 | For cabbage, cauliflower. |
| | | | | | 14 | Broccoli, Brussels sprouts. Use high rate on cabbage loopers. |
| azinphos-methyl[3] | organophosphate | Guthion Solupak 50 WP[3] | 1.12–1.75 kg | 0.4–0.7 kg | 7 | Brussels sprouts. Maximum 3 applications per year. |
| | | | | | 15 | Broccoli, cauliflower. Maximum 3 applications per year. |
| | | | | | 21 | Cabbage. Maximum 3 applications per year. |
| | | APM 50 W[3] | 1.1–1.75 kg | 0.4–0.7 kg | 7 | Brussels sprouts. Maximum 3 applications per year. |
| | | | | | 15 | Broccoli, cauliflower. Maximum 3 applications per year. |
| | | | | | 21 | Cabbage. Maximum 3 applications per year. |
| | | Sniper 240 E[3] | 2.25–3.5 L | 0.9–1.4 L | 7 | Brussels sprouts. Maximum 3 applications per year. |
| | | | | | 15 | Broccoli, cauliflower. Maximum 3 applications per year. |
| | | | | | 21 | Cabbage. Maximum 3 applications per year. |
| parathion | organophosphate | Parathion 960E | 375–590 mL | 150–235 mL | 14 | Not on kohlrabi, horseradish. Minimum period for re-entry is 7 days. |
| acephate | organophosphate | Orthene SP | 0.75–1.1 kg | 0.3–0.4 kg | 28 | Maximum 4 applications per year. Not on broccoli, kale, kohlrabi, horseradish. |

[1] Days to Harvest Interval.

[2] Do not use on muck soils.

[3] 48-hour re-entry period.

**Table 6–27.**
**Aphid Control Recommendations for Cole Crops**

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| dimethoate | organophosphate | Cygon 480 E | 0.7–1.0 L | 0.28–0.4 mL | 4 | Cabbage, cauliflower, broccoli. |
| | | | | | 7 | Kale. |
| | | | | | 21 | Brussels sprouts. Use low rate on Brussels sprouts. |
| | | Lagon 480 E | 0.7–1.0 L | 280–400 mL | 4 | Cabbage, cauliflower, broccoli. |
| | | | | | 7 | Kale. |
| | | | | | 21 | Brussels sprouts. Use low rate on Brussels sprouts. |
| methamidophos | organophosphate | Monitor 480 | 1.1–2.25 L | 0.4–0.9 L | 7 | Cabbage, cauliflower. 48-hr re-entry period. |
| | | | | | 14 | Broccoli, Brussels sprouts. 48-hr re-entry period. |
| naled | organophosphate | Dibrom EC | 1.1 L | 0.4 L | 4 | Not on kohlrabi, horseradish. |
| acephate | organophosphate | Orthene SP | 0.75–1.1 kg | 0.3–0.4 kg | 28 | Not on broccoli, kale, kohlrabi, horseradish. Maximum of 4 applications per year. |

[1] Days to Harvest Interval.

Secondary rot organisms such as *Erwinia sp.* can follow tipburn. Many varieties of cabbage and cauliflower have been noted to be resistant to tipburn problems. See the section *Calcium*, on page 14, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### Cauliflower Buttoning

Buttoning is the premature formation of a cauliflower curd. Because the curd forms very early in the plant's life, the leaves are not large enough to nourish the curd to a marketable size. Buttoning usually occurs shortly after planting in the field.

Losses are usually most severe in the early-planted crop during cold, wet seasons, when vegetative growth is reduced. Conditions that reduce the vigour of the plant and retard vegetative growth appear to encourage buttoning. Some cultivars, particularly early ones, are more susceptible to buttoning. Conditions that may cause buttoning include:

- too-rapid hardening-off treatment of young plants raised under protection
- insufficient hardening-off treatment of young plants before being planted in the field
- unbalanced soil fertility in the field (particularly low nitrogen)
- low soil moisture
- cold weather (e.g., 4°C–10°C for 10 days or more) especially in combination with excess moisture
- certain diseases, insects and trace-element deficiencies, such as club root, root maggot and molybdenum deficiency (whiptail)

**Integrated Pest Management**

Consult *Integrated Pest Management for Crucifers in Ontario*, Order No. 701, for a complete guide to integrated pest management.

**Visit the vegetable page on the OMAF Web site at**
**www.gov.on.ca/OMAF/english/crops/hort/vegetable.html**

# CUCURBITS

## CUCUMBER, MUSKMELON, WATERMELON, PUMPKIN, SQUASH (ALSO KNOWN AS VINE CROPS)

### Cultivars

The varieties listed in Table 6–28, *Suggested Cucurbit Crop Cultivars*, below, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under their local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

**Table 6–28.**
**Suggested Cucurbit Crop Cultivars**

| CUCUMBER | MUSKMELON | WATERMELON[1] | PUMPKIN | SQUASH (WINTER) | SQUASH (SUMMER) |
|---|---|---|---|---|---|
| ***Fresh*** | Cordelle | ***Seedless Types*** | ***Large (6–10 kg)*** | ***Buttercup*** | ***Marrow*** |
| Dasher II | Early Dawn | Millionaire | Magic Lantern PMT[2] | Sweet Mama (cupless) | Vegetable Marrow Bush |
| Greensleeves | Rising Star | Crimson Trio | Jack-O-Lantern | | Ghada |
| Speedway | Athena[3] | King-of-Hearts | Pankow's Field | ***Butternut*** | |
| Jazzer | Pulsar | Tiffany | Howden | Supreme | ***Straight Neck*** |
| Turbo | Starfire | Constitution | Merlin PMT[2] | Ultra | Fortune |
| General Lee | Superstar | | Goldrush | | Sunray |
| | Summet[4] | ***Icebox (Round) Types*** | Ol' Zeb | ***Delicious*** | General Patton |
| ***Processing:*** | Sugarbowl | Sugar Baby | Pro Gold 510 | Golden Delicious | |
| ***Hand Pick*** | Eclipse | Jade Star | | Green Delicious | ***Scallop*** |
| Bradley C | | Tiger Baby | ***Medium (3–5 kg)*** | | White Bush Scallop |
| Fancipak | | Sugar Doll | Mystic | ***Acorn (Pepper)*** | Peter Pan (Light Green) |
| Flurry M | | | Jack-of-all-trades | Taybelle PM | Sunburst (Yellow) |
| Vlasset B | | ***Yellow/Orange Flesh Types*** | Wizard | Table Queen (late) | |
| Patton | | New Queen (round) | Ghost Rider | Mesa Queen | ***Zucchini (green)*** |
| Pik-Rite | | Yellow Doll (round) | | | Elite |
| Score | | Solid Gold (round) | ***Small (1–2 kg)*** | ***Novelty Squash*** | Select |
| Triplemech | | Treasure Chest (seedless) | Spooktacular | Pink Banana | Embassy |
| | | Triton (seedless) | Oz | Spaghetti | Tigress ZYMV[5] |
| ***Processing:*** | | Honey Heart (Oblong) | Small Sugar | Large Turks' Turban | |
| ***Once-Over*** | | | | | ***Zucchini (yellow)*** |
| Atlantis | | ***Picnic (Oblong) Types*** | ***Mini*** | ***Sweet Potato*** | Gold Finger |
| Discover M | | Sangria | Sweetie Pie | Delicata (long) | Gold Rush |
| Lafayette | | Royal Sweet | Baby Boo (white) | Sweet Dumpling (round) | |
| Napoleon | | Stars n' Stripes | Munchkin | | |
| Royal | | Fiesta | L'il Goblin | ***Hubbard*** | |
| Vlaspik M | | Sentinel | L'il Ironsides | Kitchenette | |
| | | Mardi Gras | | Mini-Green | |
| | | Oasis | | | |
| | | Paradise | | | |

---

[1] Availability is subject to WFB (Watermelon Fruit Blotch) certification.
[2] PMT = powdery mildew-tolerant
[3] Tolerant to fusarium.
[4] Resistant to powdery mildew.
[5] Tolerant to zucchini yellows mosaic virus.

### Table 6–29.
### Common Spacings for Cucurbit Crops

| | Row Spacing | In-Row Spacing | Seeding Rate (per acre) |
|---|---|---|---|
| **Cucumbers** | | | |
| Fresh | 1.2–1.8 m<br>(4–6 ft) | 30 cm<br>(12 in.) | 0.5–1 kg<br>(1.5–2 lb) |
| **Cucumbers (processing)** | | | |
| Handpick | 1.1–1.2 m<br>(3.5–4 ft) | 10–15 cm<br>(4–6 in.) | 0.5–1 kg<br>(1.5–2 lb) |
| Machine harvest | 50–70 cm<br>(20–30 in.) | 10 cm<br>(4 in.) | 2–3 kg<br>(5–7 lb) |
| **Pumpkins & Squash**[1] | | | |
| Standard types | 1.5–3 m<br>(5–10 ft) | 120–150 cm<br>(4–5 ft) | 1–2 kg<br>(2–4 lb) |
| Semi-bush types | 1.2–1.5 m<br>(4–5 ft) | 45–60 cm<br>(1.5–2 ft) | 1.3–2 kg<br>(3–4 lb) |
| Small bush types | 0.9–1.2 m<br>(3–4 ft) | 45–60 cm<br>(1.5–2 ft) | 2–3 kg<br>(4–6 lb) |
| **Melons**[2] | | | |
| Muskmelons | 1.5–1.8 m<br>(5–6 ft) | 60–90 cm<br>(2–3 ft) | n/a[2] |
| Watermelons | 1.8–3 m<br>(6–10 ft) | 90–120 cm<br>(3–4 ft) | n/a[2] |

[1] Varieties with large fruit size (over 30 lb) will benefit from wider rows and plant spacings.

[2] Approximately 2.2 kg of seed are required to produce enough melon seedlings for 1 ha.

## Note on Processing Cucumbers

All the cultivars listed are hybrids that have a predominately female flowering habit. A true gynoecious cucumber bears only female flowers. However, not all hybrids produce 100% female flowers. As many as 80% of the plants of many new hybrids may have some male flowers in Ontario fields. Ontario day-lengths and temperatures may be responsible for the presence of male flowers on these hybrids. All gynoecious hybrid seed contains 10%–15% standard or monoecious cultivar, added as a pollinator. For satisfactory fruit set, 10%–20% of the plants should contain a large number of male flowers.

## Seeding and Spacing

See Table 6–29, *Common Spacings for Cucurbit Crops*, above.

Total cucurbit yields tend to increase with plant density. Processing cucumbers for machine harvest benefit the most from close spacings. In other vine crops, high plant populations may result in harvest problems due to excessive vine growth. An overly dense canopy is also more conducive to disease pressure.

In pumpkins and squash, fruit size tends to decrease as plant density increases. Larger sized pumpkin and winter squash varieties will benefit from wider spacing. However, extremely wide rows are slow to close canopy, resulting in higher levels of weed pressure.

## Planting

Quick, uniform emergence is essential to avoid uneven stands weakened by insects and disease. Cucurbit seeds will not germinate at a soil temperature below 10°C. They germinate fastest at 25°C–30°C soil temperatures. Delay planting until the soil temperature is 15°C or higher.

Pickling cucumbers are usually field-seeded from late May to early June for the hand-pick crop. Seeding for once-over mechanical harvesting can be done until mid-July depending on processor specifications. Pumpkins and squash for the Hallowe'en market are usually seeded in late May or early June. Plant melon transplants after the risk of spring frost has passed (see Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 30).

Plant seeds 2–2.5 cm (0.8–1 in.) deep, into moisture. Deeply planted seed is often slow to emerge, resulting in lower plant populations.

For information on producing melon transplants, see the section *Vegetable Transplants*, on page 151.

## Seedless Watermelon Production

Most seedless watermelon varieties mature in 75–90 days from transplanting, and produce round-to-oval fruit that average 5–8 kg in weight.

Triploid watermelons will not set fruit unless pollinated by a normal (diploid) watermelon variety. Interplant the pollinator variety with 2 rows of the seedless variety to 1 row of the pollinator. Plant a pollinator with a different fruit type to distinguish it from the seedless variety at time of harvest. Under cool growing conditions, some seed development may occur in seedless watermelons.

## Pollination

All the vine crops depend on insects to transfer pollen from the male to the female blossoms. Each female blossom must be visited 15–20 times in order for adequate pollination to occur. Poorly pollinated fruit will usually exhibit awkward shape and poor size.

In small plantings, there may be enough native pollinating insects to perform this function. In large plantings, the grower is advised to introduce one colony of honeybees for every hectare. Aim to have the hives in the field at first bloom.

Insecticides will poison bees. Spray only in the evening or at night, after bees have finished foraging for the day. If possible, remove hives from the field prior to spraying. See the section *Prevent Bee Poisoning*, on page 6.

For more information, consult the OMAF Factsheet, *Pollination of Vine Crops*, Order No. 87-043.

## Fertility

### Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

Apply up to 110 kg N/ha. Broadcast 65 kg N/ha and all of the phosphate and potash required. The remainder of the nitrogen should be side-dressed before the vines start to run. On sandy soils, a second application may be necessary after the vines begin to run, especially following heavy rains.

Alternatively, up to 100 kg of $(N + K_2O)$/ha can be applied in a band, 5 cm to the side and 5 cm below the seed at planting. The remainder of the fertilizer requirements should be broadcast before planting.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.) If phosphate and potash are required, they should be applied prior to planting.

For recommended fertigation application rates, refer to Table 4–10, *Nitrogen and Potash Injection Schedules*, on page 37.

## Disease Management

### Damping-Off

Seed treated with thiram (dithiocarbamate group) will help prevent damping-off, seedling blight and seed decay. Use 50 g of Thiram 75 WP for every 25 kg of seed. Use sterile soil or soil-less mix for growing seedlings.

### Bacterial Wilt

This disease overwinters in the stomachs of adult cucumber beetles. Plants become susceptible as soon as the beetles emerge in the spring. Bacterial wilt moves in the vascular system of infected plants. As a result, there is no effective treatment. Beetles must be controlled (see the section *Striped Cucumber Beetle, Spotted Cucumber Beetle (aka Southern Corn Rootworm)*, on page 80.

Cultivars vary in their susceptibility to bacterial wilt.

### Angular Leaf Spot

It is not possible to completely control this disease with fungicides. A reduction in disease severity may be achieved by spraying with a copper fungicide. Repeat at weekly intervals in wet weather. Do not work in crop when foliage is wet. See Table 6–30, *Cucurbit Disease Control Recommendations*, on page 80.

### Fusarium Wilt (Muskmelon)

Sterilize soil for melon transplants. Grow cultivars resistant to fusarium wilt in infested soils (consult seed catalogues).

### Cucumber Mosaic (Virus)

This virus is transmitted by aphids and cucumber beetles. Transmission occurs very quickly (in less than 1 minute.) As a result, aphid control will not necessarily prevent an infestation. Use of resistant cultivars is the best means of preventing yield losses.

Control perennial weeds in adjacent fencerows. Milkweed, ground cherry, pokeweed, chickweed and motherwort are alternative hosts to the mosaic virus.

### Alternaria Leaf Spot

This disease is often prevalent in muskmelons. The oldest leaves are infected first. Sprays applied to control scab and anthracnose are somewhat effective at controlling alternaria.

### Scab

This disease is more prevalent during cool weather conditions. It requires the occurrence of frequent rains or heavy dews. Fungicide sprays are not always completely effective at controlling scab. Plant cultivars resistant to scab, if they are available. Follow a 2-year rotation away from all vine crops.

### Anthracnose

Use resistant varieties where possible and follow a 2-year rotation away from vine crops. Begin fungicide applications at the first sign of disease or if weather conditions

### Table 6–30.
### Cucurbit Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Angular Leaf Spot** | | | | | | |
| copper sulphate/ copper hydroxide | inorganic | Copper 53 W | 2.5–3.0 kg | 1–1.2 kg | 1 | |
| | | Kocide 101 WP | 2.25–3.25 kg | 0.9–1.3 kg | 1 | Cucumbers only. |
| | | Copper Spray | 4.0 kg | 1.6 kg | 1 | |
| **Scab and Anthracnose** | | | | | | |
| chlorothalonil | chloronitrile | Bravo 500 | 4.8 L | 1.9 kg | 1 | |
| mancozeb | dithiocarbamate | Dithane DG | 1.1–3.25 kg | 0.44–1.3 kg | 14 | |
| | | Manzate DF | 2.25–3.25 kg | 0.9–1.3 kg | 14 | Cucumbers. |
| | | Penncozeb 80 WP | 1.1–3.25 kg | 0.44–1.3 kg | 14 | |
| benomyl | benzimadazole | Benlate 50 WP | 550–850 g<br>+ mancozeb (above) | 220–340 g<br>+ mancozeb (above) | 14 | Scab only. |
| captan | phthalimide | Maestro 75 DF | 2.5–4.5 kg | 1–1.8 kg | 2 | Cucumber only.<br>Use low rate on young plants. |
| | | Captan 80 WDG | 2.0–4.2 kg | 0.8–1.7 kg | 2 | |
| copper sulfate | inorganic | Copper 53 W | 2.5–3 kg | 1–1.2 kg | 1 | Anthracnose only. |
| **Powdery Mildew** | | | | | | |
| chlorothalonil | chloronitrile | Bravo 500 | 4.8 L | 1.9 kg | 1 | |
| benomyl | benzimadazole | Benlate 50 WP<br>+ mancozeb (above) | 550–750 g<br>+ mancozeb (above) | 220–340 g<br>+ mancozeb (above) | 14 | |

[1] Days to Harvest Interval.

are favourable (cool and wet). Spray with one of the fungicides recommended in Table 6–30, *Cucurbit Disease Control Recommendations*, above.

### Powdery Mildew

This disease generally appears in late July to early August. In all vine crops, severe infections can reduce yield. The sugar content of melons and squash may be reduced in plants affected by powdery mildew. In pumpkins, mildew will cause the stems (handles) to break down prematurely.

As soon as mildew appears, apply one of the fungicides recommended in Table 6–30, *Cucurbit Disease Control Recommendations*, above, at 8- to 10-day intervals. Look for new powdery mildew–resistant varieties on the market.

## Insect Management

### Seedcorn Maggot and Wireworm

See the sections *Seedcorn Maggot*, on page 45, and *Wireworm*, on page 44.

### Squash Vine Borer

Fleshy, white larvae feed inside the stems and fruit of gourds, pumpkins and squash. This pest is rarely a problem in commercial fields as borers are generally controlled by cucumber beetle sprays. If a problem occurs, spray the base of plants thoroughly with one of the insecticides recommended in Table 6–31, *Cucurbit Insect Control Recommendations*, on page 81.

### Striped Cucumber Beetle, Spotted Cucumber Beetle (AKA Southern Corn Rootworm)

Beetles usually arrive in cucurbit fields as the crop begins to emerge. They can cause significant damage to young seedlings. Beetles must be controlled to prevent the transmission of bacterial wilt.

Spray when beetles first appear in the field. A general guideline is to treat when beetles exceed 0.5–1 per plant. A follow-up spray may be necessary, as beetle emergence is often staggered.

Cucumber beetles tend to congregate in certain areas of the field, making them an excellent candidate for spot spraying. Refer to Table 6–31, *Cucurbit Insect Control Recommendations*, on page 81, for a list of recommended products.

### Aphids

Begin monitoring for aphids in late June, especially during hot, dry weather conditions. Aphids are vectors of virus diseases. Focus monitoring efforts on runners. If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–31, *Cucurbit Insect Control Recommendations*, on page 81.

## Table 6–31.
## Cucurbit Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Squash Vine Borer[2]** | | | | | | |
| **Spray** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.0 kg | 0.4 kg | 2 | |
| | | Endosulfan 50 W | 1.1 kg | 0.44 kg | 2 | |
| | | Thiodan 4 EC | 1.5 L | 0.6 L | 2 | |
| rotenone | botanical | Rotenone 5 WP | 4.5 kg | 1.8 kg | 1 | |
| **Dust** | | | | | | |
| rotenone | botanical | Rotenone 1% WP | 40 kg | 16 kg | 1 | |
| **Cucumber Beetle** | | | | | | |
| **Spray** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.0 kg | 0.4 kg | 2 | |
| | | Endosulfan 50 W | 1.1 kg | 0.44 kg | 2 | |
| | | Thiodan 4 EC | 1.5 L | 0.6 L | 2 | |
| azinphos-methyl | organophosphate | Guthion 240 SC | 2.25 L | 0.9 L | 6 | **Cucumbers.**<br>7 days between applications.<br>Maximum 3 applications/yr.<br>48-hr re-entry period. |
| | | Sniper 240 E | 2.25 L | 0.9 L | | |
| | | Guthion Solupak 50 WP | 1.12 kg | 0.45 kg | 14 | **Melons and pumpkins:**<br>5 days between applications.<br>Maximum 2 applications/yr.<br>48-hr re-entry period. |
| methoxychlor | diphenylethane | Methoxychlor 240 | 3–9 L | 1.2-3.6 L | 1 | Do not use on melons.<br>Will also control leafhoppers. |
| **Dust** | | | | | | |
| rotenone | botanical | Rotenone 1% WP | 40 kg | 16 kg | 1 | |
| **Aphids** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.0 kg | 0.4 kg | 2 | |
| | | Endosulfan 50 W | 1.1 kg | 0.44 kg | 2 | |
| | | Thiodan 4 EC | 1.5 L | 0.6 L | 2 | |
| malathion | organophosphate | Malathion 25 W | 4.25 kg | 1.7 kg | 3 | Will also control leafhoppers. |
| | | | 4.0–5.5 kg | 1.6–2.2 kg | 3 | Melons. |
| | | Malathion 500 E | 1.8 L | 0.72 L | 3 | Will also control leafhoppers. |
| | | | 2.25–2.75 L | 0.9-1.1 L | 3 | Melons. |
| **Two-Spotted Spider Mite** | | | | | | |
| dicofol | diphenylethane | Kelthane 50 W | 1.0–1.25 kg | 0.4-0.5 kg | 7 | Maximum 1 application/yr. |
| **Cutworms[3]** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.2–2.4 L | 0.48-0.96 L | 60 | Cucumbers only. |
| | | Pyrinex 480 EC | 1.2–2.4 L | 0.48-0.96 L | 60 | Cucumbers only. |
| carbaryl | carbamate | Sevin XLR plus | 2.5 L | 1 L | 5 | Climbing cutworms only. |

[1] DHI = Days to Harvest Interval.
[2] Butternut squash is resistant to squash vine borer.
[3] Seedling treatments.

### Leafhoppers

High levels of leafhoppers occasionally appear in vine crops after hay is cut in the spring. Feeding damage plugs the vascular system, causing hopper burn. Hopperburn is frequently mistaken for drought stress. If hoppers are found feeding in the crop, see Table 6–31, *Cucurbit Insect Control Recommendations*, on page 81.

### Squash Bug

The squash bug is primarily a pest of pumpkin, squash and zucchini but can be found on any cucurbit crop. The squash bug overwinters as an adult in sheltered areas and emerges during mid-summer. Crop rotation and field sanitation are the best methods for managing this pest.

### Two-Spotted Spider Mite

Mites move into the crop from grassy field margins. A well-timed border spray will often provide efficient control. This pest is often more prevalent in hot, dry summers. If monitoring indicates a need, spray as recommended in Table 6–31, *Cucurbit Insect Control Recommendations*, on page 81.

### Sap Beetle (Melons)

Beetles infest and damage ripening fruit where the stem is attached to the vine and where the skin is diseased or injured. To reduce beetle injury, harvest the melons as often as possible (at the half-slip stage). Remove all damaged fruit and culls from the field.

**Bee Warning**

Except for rotenone, the insecticides listed in Table 6–31, *Cucurbit Insect Control Recommendations*, on page 81, are toxic to bees. Apply insecticides in the evening when bees are not working in the field. If hives are in the crop, remove them when treating the field.

**Table 6–32.**
**Pumpkin and Squash Storage Expectancy**

| Type | Storage Expectancy |
|---|---|
| Acorn | 4–7 weeks |
| Pumpkins | 8–12 weeks |
| Butternut | 8–12 weeks |
| Buttercup | 10 weeks |
| Turban | 12 weeks |
| Hubbard | 6 months |

## Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 45.

## Curing and Storing Pumpkin and Squash

Curing the fruit for 10–20 days at 24°C–27°C can decrease its higher water content and improve its eating quality. Butternut, hubbard and delicious cultivars respond to this treatment, but storage life may be shortened. Curing acorn-type squashes decreases the storage life and eating quality.

- Maintain storage temperatures between 10°C–15°C. Pumpkin and squash are susceptible to cold injury, which appears after the fruit has been brought to room temperature.
- Aim for 50%–70% relative humidity. High humidity levels will increase storage rots, while dry conditions will increase weight loss and shrinkage. Weight loss should be kept below 15%.

See Table 6–32, *Pumpkin and Squash Storage Expectancy*, above, for more details.

# EGGPLANT

## Cultivars

Table 6–33, *Suggested Eggplant Cultivars*, right, lists varieties with disease-resistant traits available in the market. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Seed and Spacing

| | |
|---|---|
| **Row Spacing:** | 90–120 cm (36–48 in.) |
| **In-Row Spacing:** | 45–60 cm (18–24 in.) |
| **Rate:** | Approximately 200–300 g of seed will produce enough plants for 1 ha. |

## Fertility

### Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

Apply up to 70 kg N/ha. Broadcast 35 kg N/ha and all of the required phosphate and potash before planting. The remainder of the nitrogen should be side-dressed, 3–4 weeks after field setting.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.)

### Starter Solution

At transplanting, apply a high-phosphorous starter solution such as, 1 L of 10-34-0 per 100 L of water or 1 L of 6-24-6 per 75 L of water. Under high temperature conditions or on dry sandy soils, reduce the amount of fertilizer by one-half but continue to use the same volume of water. This will reduce the risk of crop injury under these growing conditions.

## Disease Management

### Seed Treatment

Sow hot-water-treated seed (see the section *Hot-Water Treatment*, on page 152). To prevent damping-off, use sterile soil-less mix and treat seed with thiram (dithiocarbamate group) seed protectant. Use 65–80 g of Thiram 75 WP per 25 kg of seed.

**Table 6–33.**
**Suggested Eggplant Cultivars**

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| Megal | Seedway | 60 | Tolerant to tobacco mosaic virus. Long, tapered, purple-black. |
| Vittoria | Norseco, Rupp | 61–62 | Tolerant to tobacco mosaic virus. Long, cylindrical, dark purple. |
| Dusky | Norseco, Seedway, Rupp | 58–64 | Tolerant to tobacco mosaic virus. Bell type, purple. |
| Epic | Rupp, Seminis | 64 | Tolerant to tobacco mosaic virus. Bell-type, purple-black. |

### Verticillium Wilt

Sow and transplant in steamed or fumigated soil. Do not plant in fields where verticillium wilt has been present unless the soil has been fumigated. Good weed control is an important part of wilt control. A higher incidence of wilt may occur following peppers, tomatoes, eggplant, potatoes, strawberries and raspberries.

### Phomopsis Blight

Avoid planting in infested fields for 3 years.

## Insect Management

### Flea Beetles

Begin monitoring for flea beetles as soon as the transplants are set in the field. If beetles are found, apply one of the insecticides listed in Table 6–34, *Eggplant Insect Control Recommendations*, on page 84.

### Aphids

If monitoring indicates a need, spray with one of the insecticides listed in Table 6–34, *Eggplant Insect Control Recommendations*, on page 84.

### Tarnished Plant Bug

Monitoring for tarnished plant bugs should begin at the time of flowering. If necessary, apply one of the insecticides listed in Table 6–34, *Eggplant Insect Control Recommendations*, on page 84.

For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

## Table 6–34.
## Eggplant Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] |
|---|---|---|---|---|---|
| **Flea Beetles** | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1–2.25 kg | 0.4–0.9 kg | 2 |
| | | Thiodan 4 EC | 1.5–2.75 L | 0.6–1.1 L | 2 |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 2 |
| carbaryl | carbamate | Sevin XLR Plus | 1.25–2.5 L | 0.5–1 L | 2 |
| **Aphids** | | | | | |
| endosulfan[2] | chlorinated cyclodiene | Thiodan 50 WP | 1–2.25 kg | 0.4–0.9 kg | 2 |
| | | Thiodan 4 EC | 1.5–2.75 L | 0.6–1.1 L | 2 |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 2 |
| **Tarnished Plant Bug** | | | | | |
| dimethoate | organophosphate | Cygon 480 E | 0.5–0.7 L | 0.2–0.28 L | 7 |
| | | Lagon 480 E | 0.5–0.7 L | 0.2–0.28 L | 7 |
| **Colorado Potato Beetle** | | | | | |
| carbaryl | carbamate | Sevin XLR Plus | 1.25–2.5 L | 0.5–1 L | 2 |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1–2.25 kg | 0.4–0.9 kg | 2 |
| | | Thiodan 4 EC | 1.5–2.75 L | 0.6–1.1 L | 2 |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 2 |

[1] DHI = Days to Harvest Interval.

[2] The green peach aphid is resistant to these insecticides in some areas.

### *Colorado Potato Beetle*

If monitoring indicates a need, spray with one of the insecticides listed in Table 6–34, *Eggplant Insect Control Recommendations*, above.

**Note:** The Colorado potato beetle shows resistance to a number of registered insecticides in many areas. Do a dip test before spraying. See the OMAF Factsheet, *Colorado Potato Beetle Dip Test*, Order No. 92-028.

### Nematode Control

See the section *Nematodes*, on page 45, for nematode control recommendations.

**See Chapter 5, *Integrated Pest Management*, on page 41, for suggestions on how to improve pest management.**

# GARLIC

## Cultivars

The recommended cultivars in Ontario are the Music strains.

**Note:** Cultivated garlic plants do not produce true seed. All garlic is propagated vegetatively. Two types of garlic are grown in Ontario and are described as either "hardneck" or "softneck." For seed sources, consult the Ontario Garlic Growers Association (www.garlicgrowers.on.ca).

## Seeding and Spacing

The optimum planting date is from September to late October with October 15 being ideal most years. To estimate the planting date, use the average date for the first fall frost for the area in which garlic is to be grown and begin planting on this date. See Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 30.

| | |
|---|---|
| **Row Spacing:** | 20 cm (8 in.) |
| **In-Row Spacing:** | 7–12 cm (3–5 in.). Use wider spacing in lighter, drought-prone soils. |
| **Rate:** | 700–1,000 kg of cloves/ha. |
| **Depth of Planting:** | Allow for 3–5 cm (1–2 in.) between the soil surface and the top of the clove. |

## Soils

Garlic can be grown on a wide range of soil types providing the soils are well-drained, deep and fertile. Soils with good organic matter content are preferred due to the increased moisture and nutrient holding capacity. Extremely heavy soil types should be avoided.

Soil pH should range from 6.0–7.5. Low pH soils, such as 5.0–5.5 or less, will result in very poor yields and plant stands.

## Fertility

### Nitrogen

On mineral soils, a total of 110 kg nitrogen/ha is required. Calcium nitrate or calcium ammonium nitrate are the preferred sources. Apply half the nitrogen as soon as the garlic plants begin to grow in the spring. Apply the rest of the nitrogen in 2–3 side-dresses at 3-week intervals.

### Phosphate and Potash

Use a soil test to establish pH, phosphorus and potassium requirements. Amend soil pH, phosphorus and potassium levels prior to fall planting. Phosphorus and potassium requirements are similar to those for onions.

## Irrigation

Garlic is shallow-rooted and sensitive to moisture stress. For most soil types, approximately 2.5 cm of water is required per week. On very dry sandy soils, as much as 5.0 cm is required weekly.

## Disease Management

### Penicillium (Green Mould)

Green mould disease, caused by the fungus *Penicillium*, attacks cloves that have been damaged prior to planting. Affected cloves may fail to emerge in the spring or may produce weak, stunted plants that soon die. Plant only clonal cultivars known to be vigorous under Ontario growing conditions.

Avoid damaging the seed cloves, especially during the cracking procedure. Many mechanized cracking devices cause excessive amounts of clove damage. Crack the seed immediately before it is to be planted. Cloves may be treated with one of the fungicides listed in Table 6–35, *Garlic Disease and Insect Control Recommendations*, on page 86.

### White Rot

See the section *White Rot*, on page 97. Control options are listed in Table 6–35, *Garlic Disease and Insect Control Recommendations*, on page 86.

### Basal Rot

See the section *Basal Rot*, on page 96.

## Insect Management

### Aphids, Thrips and Onion Maggot

See Table 6–35, *Garlic Disease and Insect Control Recommendations*, on page 86. For further details, consult the OMAF Factsheets, *Garlic Production*, Order No. 97-007, and *Onion Maggot Control*, Order No. 00-017.

## Table 6–35.
## Garlic Disease and Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Penicillium or Green Mould Disease** | | | | | | |
| iprodione | dicarboximide | Rovral 50 WP | 4 g/L of water | | | Dip cloves into the Rovral suspension for 30 minutes immediately before planting. |
| **White Rot** | | | | | | |
| dicloran | quinone | Botran 75 W | 6.75–11.0 kg | 2.7–4.4 kg | | **Spring Planting**<br>Apply 1–2 weeks prior to planting and work into top 4 cm of soil. |
| | | | 36.0–44.0 kg | 14.4–17.6 kg | | **Fall Planting**<br>Apply 1–2 weeks prior to planting and work into top 4 cm of soil. |
| **Aphids, Thrips** | | | | | | |
| malathion | organophosphate | Malathion 500 E | 1.1–2.75 L | 0.44–1.1 L | 3 | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 188 mL | 75.2 mL | 14 | Thrips only.<br>Do not use more than 3 times per season.<br>24-hr re-entry period. |
| **Onion Maggot** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 3.5 L in 1,000 L of water | 1.4 L in 400 L of water | 50 | Apply as a drench over the row on newly emerged plants (in the spring). |
| | | Pyrinex 480 EC | 3.5 L in 1,000 L of water | 1.4 L in 400 L of water | 50 | Apply as a drench over the row on newly emerged plants (in the spring). |

[1] DHI = Days to Harvest Interval.

**Visit the vegetable page on the OMAF Web site at**
**www.gov.on.ca/OMAF/english/crops/hort/vegetable.html**

# HERBS

In general, herbs do best in full sunlight (chervil requires partial shade), in a protected location. They are best suited to well-drained, sandy loam soils that are slightly acidic and fertile. (Thyme prefers calcareous soils.) Excessive fertility can reduce essential oils and fragrances in the leaf tissue of actively growing herbs.

## Propagation

Methods of propagation vary dramatically. Each herb type may require specialized treatment for germination rate and seedling vigour. The method of propagation may vary depending on whether the supplier is offering bunches, custom orders or trays of live plants. It is essential to procure proper strains of certain herbs such as French tarragon. Purchase stock only from sources using marketable strains.

## Overwintering Perennial Herbs

Straw mulching (wheat preferred) may be used to protect roots during the dormant season for perennials.

## Fertility and Irrigation

Soils should be moderately fertile. A regular soil test should form the basis of any fertility program as well as regular incorporation of organic matter. Excessive use of nitrogen will produce weakly flavoured leaf and stem tissue. Herbs are generally more drought-tolerant than most vegetable crops. Water only when signs of wilt are evident. Mint may require irrigation at key times during production.

## Field Spacing

Space needs can vary considerably between the herbs. In-row spacing can vary from 20 cm (8 in.) for anise, parsley or sweet marjoram to 75 cm (30 in.) for coriander, dill, fennel and rosemary. Between-row spacing can vary from 90–120 cm (36–48 in.) depending on cultivation practices.

## Disease and Insect Management

Insects and diseases (such as mildew in rosemary or septoria leaf blight, bacterial blight and clover worm in parsley) can affect many herbs. Various leaf-feeding caterpillars and aphids can be found on many species. Regular scouting activity can detect an outbreak of a certain pest before a serious infestation results.

## Competition Control and Mulching

A variety of methods of weed control are practised in herb plantings. Cultivation is perhaps the most useful tool. Mulches can help but may be costly. Consult a crop specialist regarding herbicide registrations in various herb crops as well as Chapter 7, *Weed Management for Vegetable Crops*, on page 157. Plastic mulch in combination with drip irrigation may be useful in some situations.

**Table 6–36.**
**Herb Type, Propagation, Parts Harvested/Sold**

| Herbs | Propagation | Leaves | | Whole Shoot | | Ripe, Dry Fruit | Flowers |
|---|---|---|---|---|---|---|---|
| | | Fresh | Dried | Fresh | Dried | | |
| **Annuals** | | | | | | | |
| Anise | S[1] | X | | | | X | |
| Borage | S[1] | X | X | | | X | X |
| Caraway | S | | | | | X | |
| Chervil | S[1] | X | X | X | X | | |
| Coriander | S[1] | X | X | | | X | |
| Dill | S[1] | X | X | X | | X | |
| Fennel | S[1] | X | X | X | X | X | |
| Parsley[2] | S[1] | X | X | | | | |
| Sweet basil | S[3] | | | X | X | | |
| Sweet marjoram | S[3] | | | | X | | |
| Summer savory | S | | | | X | | |
| **Perennials** | | | | | | | |
| Chives (bulb) | C, R, S[3] | X | X | | | | |
| Lavender | C, R, S[4] | | | | | | X |
| Lemon verbena | C, R | X | X | | | | |
| Mint | C, R | X | X | X | X | | |
| Oregano | C, R, S[3] | | | | X | | |
| Rosemary (non-hardy) | C, R, S[4] | X | X | | | | X |
| Sage | C, R, S[3] | X | X | X | X | | |
| Tarragon | C, R | | | | X | | |
| Thyme | C, R, S[3] | | | | X | | |

C = cutting; S = seed; R = root division

[1] Direct seeding is best for field production.
[2] See the section *Lettuce, Endive & Parsley*, on page 88.
[3] Direct seeding or transplants (plugs) are best for field production.
[4] Use transplant plugs for field production.

## Harvesting for Fresh Market and Dry Market

If practical, harvest in early morning after the dew has dried from the crop and before the sun dissipates the essential oils; leaves should be clean and free of dust and soil. Do not completely strip the stems of the entire leaf crop, as remaining leaves are necessary to keep the plants growing. All varieties listed are suitable for the dry market as well.

# LETTUCE, ENDIVE & PARSLEY

## Cultivars

The varieties listed in Table 6–37, *Suggested Lettuce Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Temperature

Lettuce is a cool-weather crop and grows best at temperatures between 16°C and 18°C. Production is limited on mineral soils to the transplanted early crop and the seed-sown late crop. On muck soils, in cooler areas such as Bradford, lettuce may be produced throughout the growing season.

Properly hardened transplants, when set in the field in the early spring, can tolerate temperatures as low as –7°C. For the late crop on both muck and mineral soils, seeding time is important. If plants are immature when the first frost occurs, they will recover. Wrapper leaves on mature heads are very susceptible to frost and can only be marketed at a lower grade.

Germination occurs even at 4°C. At very high soil temperatures (27°C or above), germination is delayed.

## Planting

### *Direct-Seeding*

Sow seed in spring as soon as soil is ready at a rate of 1–2 kg/ha. Use coated or pelleted seed with a precision seeder to ensure a more uniform stand and germination, reduced thinning costs and higher percentages of cut at harvest time.

**Transplants**

See the section *Vegetable Transplants*, on page 151.

### *Spacing*

| | |
|---|---|
| **Row Spacing:** | Leaf & butterhead: 30 cm (12 in.)<br>Crisphead: 40 cm (16 in.)<br>Parsley: 30–40 cm (12–16 in.) |
| **In-Row Spacing:** | Leaf & butterhead: 20–30 cm (8–12 in.)<br>Crisphead: 30–35 cm (12–14 in.)<br>Parsley: 10–15 cm (4–6 in.) |

Depending on the variety, endive can be planted similarly to crisphead lettuce.

**Table 6–37.**
**Suggested Lettuce Cultivars**

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Endive** | | | |
| Tasos | Bejo Seeds | 90 | Tolerant to cold. Finely curled leaf. |
| **Escarole** | | | |
| Eros | Bejo Seeds | 60 | Tolerant to tipburn. Broad leaf. |
| **Lettuce** | | | |
| **Boston (Bibb) and Butterhead** | | | |
| Buttercrunch | Seminis | 65 | Slow bolting, long-standing Bibb type. |
| **Cos or Romaine** | | | |
| Paris Island | Seminis | 65 | Tolerant to tipburn and bolt. Medium green. |
| Triton (Romaine) | Harris-Moran | | Dark green. |
| **Crisphead** | | | |
| Ithaca | Seminis | early, late | Medium-dark green, spring, late summer. |
| Summertime | Seminis | | |
| **Leaf** | | | |
| Grand Rapids | Seminis | 55–60 | Medium green, curled, frilled margins. |
| Geenday | Seminis | | |
| New Red Fire | Takii | | |
| Xena | Harris-Moran | | Loose leaf. |
| **Parsley** | | | |
| Kraus | Bejo Seeds | 75 | Long stalks, densely curled. |
| Fakir (root parsley) | Bejo Seeds | 85 | Long, smooth roots. |

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

**Mineral soils:** Apply up to 110 kg N/ha. Broadcast 55 kg N/ha before planting and work in. Side-dress with an additional 55 kg N/ha, 3 weeks after transplanting or after thinning the seeded crop.

**Muck soils:** Broadcast and incorporate up to 120 kg N/ha prior to planting.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.)

### Micronutrients

#### Copper

Copper deficiency may show up on acid peat and muck soils. Copper may be mixed with the fertilizer and applied at 14–29 kg copper/ha (12.5–25 lb/ac) on newly cultivated muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. Consult the section *Copper*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Manganese

Deficient lettuce shows marked yellowing between the veins, which remain dark green. Manganese deficiency usually shows up on slightly acid or alkaline muck, peat and dark-coloured sandy soils. Soil application is not recommended for manganese because of the large amounts required. If a deficiency is identified, apply foliar manganese sprays starting after thinning or transplanting. For more information, see the section *Manganese*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

#### Calcium

Under hot, dry conditions, lettuce may benefit from calcium to prevent tipburn or blackheart symptoms. See the section *Calcium*, on page 14, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Disease Management

### Damping-Off and Pythium Stunt

Steam or fumigate soil for growing transplants or use a sterile soilless mix. (See the section *Damping-Off of Seedlings*, on page 44.)

For lettuce crops, see Table 6–38, *Lettuce Seed Treatments*, below.

### Botrytis (Grey Mould)

This common fungal disease often affects tissues damaged by other diseases or insects. Water-soaked lesions followed by a grey mould on lower leaves is characteristic. Follow the recommendations in Table 6–39, *Lettuce and Parsley Disease Control Recommendations*, on page 90.

### Rhizoctonia Bottom Rot

This common, soil-borne fungus often causes a bottom rot near maturity, when leaves are touching the soil. Rust-coloured lesions followed by secondary rots are typical symptoms. Good drainage and growing on raised beds may be helpful.

### Downy Mildew

Regular and consistent monitoring and the use of disease forecasting systems help to better manage this disease. Downy mildew can be a problem in seedling greenhouses and late lettuce crops. See Table 6–39, *Lettuce and Parsley Disease Control Recommendations*, on page 90.

### Sclerotinia White Mould (Drop)

This disease affects many crops, including lettuce, carrots, beans and celery. Rotate with non-susceptible crops such as onions, beets or spinach for 2–3 years. Removal of crop refuse will help control the disease.

Use wider row and plant spacings to encourage good air movement or plant on raised beds. Spray after thinning, as detailed in Table 6–39, *Lettuce and Parsley Disease Control Recommendations*, on page 90. Direct the spray onto the lower portion of plants.

### Corky Root Rot

This problem is caused by difficult-to-detect bacteria or excess nitrogen. Allow sufficient time between lettuce crops for the plant residues to decompose completely. Avoid applying excessive amounts of nitrogen, especially urea. Most Boston types have good resistance.

**Table 6–38.**
**Lettuce Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Ridomil 2G | metalaxyl | 25 kg/ha<br>(10 kg/ac) | damping-off and pythium stunt | Apply with seed in-furrow. Use 115 g per 100 m of row. Do not use on transplants. |
| Thiram 75 WP | thiram | 90 g<br>per 25 kg of seed | damping-off | |

**Table 6–39.**
**Lettuce and Parsley Disease Control Recommendations**

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Botrytis Grey Mould** | | | | | | |
| **Greenhouse-grown seedlings** | | | | | | |
| ferbam | dithiocarbamate | Ferbam WDG | 2 kg/1,000 L water | | | Spray 76% solution to wet plants only. |
| | | Ferbam Dust | 12 kg/100 m² of bed | | | Dust before first transplanting and once or twice later at 10-day intervals. |
| **Field application** | | | | | | |
| iprodione | dicarboximide | Rovral WP | 1.5 kg | 0.6 kg | 4 | Maximum 4 applications per year.<br>Start after thinning, apply at 7-day intervals. |
| **Downy Mildew** | | | | | | |
| zineb | dithiocarbamate | Zineb 80 W | 2.25–2.5 kg | 0.9–1 kg | 10 | Lettuce only. |
| metalaxyl-m/ mancozeb | acylamine & dithiocarbamate | Ridomil Gold MZ 68 WP | 2.5 kg | 1 kg | 14 | Lettuce only.<br>Maximum 3 applications per year. |
| fosetyl-al | phosphonate | Aliette 80 WDG | 2.8 kg | 1.12 kg | 7 | Lettuce only. Maximum 5 applications per year. 12-hr re-entry period. |
| **Sclerotinia White Mould (Drop)** | | | | | | |
| dicloran | quinone | Botran 75 W | 2.3–3.75 kg | 0.9–1.5 kg | 14 | Lettuce only. Maximum 2 applications per year. |
| vinclozolin[2] | dicarboximide | Ronilan EG | 1.1 kg | 0.44 kg | 28 | Lettuce only. 12-hr re-entry period. Maximum 3 applications per year. |

[1] Days to Harvest Interval.

[2] Apply 12 days after thinning on seeded crop or 57 days after transplanting. Second and third applications may be made at 10-day intervals. Note that a 15-m buffer zone must be maintained between sprayed areas and aquatic systems such as ponds and ditches.

### Aster Yellows

The symptoms of aster yellows on lettuce and endive are bright yellowing and twisting of leaves. Crisphead types suffer poor head formation. Secondary bacterial rots often follow aster yellows. See the section *Aster Leafhopper*, on page 90, for control recommendations.

### Lettuce Mosaic Virus

Mosaic-indexed or mosaic-tested seed is available from most sources. This seed is produced in special areas where it is carefully checked to ensure that it is virtually free from seed-borne mosaic. Control aphids, which spread the disease from infected lettuce plants. Weeds such as groundsel, shepherd's-purse and lamb's-quarters are alternate hosts.

### Bacterial Wilt (Dry Leaf Spot)

This disease, caused by *Xanthomonas* bacteria, has become more prevalent in recent years. It is characterized by water-soaked, wedge-shaped spots along the leaf margins that may also become olive-coloured. Excessive nitrogen or overhead irrigation may increase disease levels. All greenhouse areas used for transplant production must be disinfected.

### Parsley Leafspot (Septoria)

This fungal disease, which is primarily seed-borne, causes greyish-brown spots with cinnamon-brown margins on leaves and petioles. Crop rotation, removal and/or deep plowing of crop residues, hot water seed treatment and careful management of overhead irrigation may reduce diseases levels. Seed-borne infections decrease in seed that is more than 2 years old.

## Insect Management

### Cutworms

Follow the recommendations listed in Table 6–40, *Lettuce, Endive and Parsley Insect Control Recommendations*, on page 91. Also see the section *Cutworms*, on page 44, for additional cutworm management recommendations.

### Aster Leafhopper

Aster leafhoppers spread the aster yellows virus. Monitor leafhoppers with a sticky trap (if checked daily) or with a

## Table 6–40.
## Lettuce, Endive and Parsley Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Cutworms** | | | | | | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 175 mL | 70 mL | 21 | Do not disturb soil for 5 days after treating. |
| permethrin | pyrethroid | Pounce | 180–390 mL | 72–156 mL | | Apply up to the 5-leaf stage. Do not disturb soil for 5 days after treating. Use high rates on muck soils. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33 mL | 3 | Head lettuce only. 24-hr re-entry. Maximum 3 applications per year. Dark-sided and white cutworms only. |
| **Aster Leafhopper** | | | | | | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 125 mL | 50 mL | 14 | Lettuce only. Maximum 4 applications per year. |
| | | Cymbush 250 EC | 200 mL | 80 mL | 14 | |
| parathion | organophosphate | Parathion 960 EC | 225–375 mL | 90–150 mL | 7 | Head lettuce. 7-day re-entry period. |
| | | | | | 21 | Leaf lettuce. 7-day re-entry period. |
| malathion | organophosphate | Malathion 500 E | 1.5–2.75 L | 0.6–1.1 L | 3 | Head lettuce. |
| | | | | | 14 | Leaf lettuce. |
| carbaryl | carbamate | Sevin XLR plus | 1.25–2.5 L | 0.5–1 L | 5 | Head lettuce. |
| | | | | | 21 | Leaf lettuce, endive, parsley. |
| **Cabbage Looper** | | | | | | |
| Bacillus thuringiensis | microbial | Dipel 2XDF | 275–550 g | 110–220 g | 0 | Lettuce & parsley only.<br>275 g/ha rate maximum for parsley. |
| | | Thuricide HPC | 2.0–4.25 L | 0.8–1.7 L | 0 | Lettuce only. |
| methomyl | carbamate | Lannate SP | 0.51–1.0 kg | 0.2–0.4 kg | 7 | Head lettuce only. 24-hr re-entry period. |
| methamidophos | organophosphate | Monitor 480 EC | 1.25–2.25 L | 0.5–0.9 kg | 14 | Head lettuce only. 48-hr re-entry period. |
| naled | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | Lettuce & endive only. |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2 L | 0.8 L | 14 | Head lettuce only.<br>Maximum 3 applications per year. |
| | | Endosulfan 50 W | 1.75 kg | 0.7 kg | 14 | |
| | | Thionex 50 WP | 1.75 kg | 0.7 kg | 14 | |
| acephate | organophosphate | Orthene SP | 0.75–1.1 kg | 0.3–0.9 kg | 7 | Head lettuce only.<br>Maximum 4 applications per year. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33 mL | 3 | Head lettuce only. Maximum 3 applications per year. 24-hr re-entry period. |
| **Tarnished Plant Bug** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2 L | 0.8 L | 14 | Head lettuce only. |
| | | Thionex 50 WP | 1.75 kg | 0.7 kg | 14 | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33 mL | 3 | Head lettuce only. Maximum 3 applications per year. 24-hr re-entry period. |

[1] DHI = Days to Harvest Interval.

sweep net to help determine when and if sprays are required. Without daily monitoring, there is no way to predict whether scheduled spraying with insecticides will provide any control.

Control weeds in headlands and ditchbanks and control aster leafhoppers on adjacent carrot and celery crops. After harvest, disk down unmarketable heads immediately.

Refer to the Aster Yellows Index (AYI) calculation in the section *Aster Leafhopper*, on page 65. Treat when the AYI equals 20–25 for head lettuce and 30–35 for romaine.

For more information, consult the OMAF Factsheet, *The Aster Leafhopper and Aster Yellows*, Order No. 98-057.

### Table 6–41. Aphid Control Recommendations for Lettuce and Parsley

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| dimethoate | organophosphate | Cygon 480 E | 700 mL | 280 mL | 7 | Lettuce only. |
| | | Lagon 480 E | 700 mL | 280 mL | 7 | |
| pirimicarb | carbamate | Pirimor DF | 300–500 g | 120–200 mL | 7 | Lettuce only. |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2 L | 0.8 L | 14 | Head lettuce only. Maximum 3 applications per year. |
| | | Endosulfan 50W | 1.75 kg | 0.7 L | 14 | |
| | | Thionex 50 WP | 1.75 kg | 0.7 L | 14 | |
| parathion[2] | organophosphate | Parathion 960 E | 225–375 mL | 90–150 mL | 7 | Head lettuce only. 7-day re-entry period. |
| | | | | | 21 | Leaf lettuce only. 7-day re-entry period. |
| methamidophos | organophosphate | Monitor 480 EC | 1.1–2.25 L | 0.44–0.9 L | 14 | Head lettuce only. 48-hr re-entry period. |
| naled[3] | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | Lettuce, endive only. |
| diazinon[3] | organophosphate | DZN 600 EW | 915 mL | 366 mL | 10 | Lettuce only. |
| | | | | | 14 | Parsley only. |
| | | Diazinon 500 | 1.1 L | 0.44 L | 10 | Lettuce only. |
| acephate | organophosphate | Orthene SP | 0.75–1.1 kg | 0.3–0.44 kg | 7 | Head lettuce only. Maximum 4 applications per year. |
| imidacloprid | chloronicotinyl | Admire 240 F | 10.2 mL per 1,000 plants | 10.2 mL per 1,000 plants | 21 | Transplant tray plug drench. **Do not follow transplant drench with soil or foliar treatments.** |
| | | Admire 240 F | 650 mL | 260 mL | 21 | Soil application (field drench). Apply after transplanting using 2,000 L water/ha. Maximum 1 application per year. |
| | | Admire 240 F | 200 mL | 80 mL | 7 | Foliar application.[4] **Do not make Admire foliar application following a plug treatment or soil drench application.** 24-hr re-entry period. |

[1] DHI = Days to Harvest Interval.

[2] The green peach aphid may be becoming resistant to this insecticide.

[3] Control of aphids with naled and diazinon has been inconsistent in many areas.

[4] **One application of Admire 240 F per crop and a maximum of 2 foliar applications per field per year are permitted.**

If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–40, *Lettuce, Endive and Parsley Insect Control Recommendations,* on page 91.

#### Treatment to Soil at Seeding Time

Two soil treatments at seeding time are also labelled:

- Apply phorate (organophosphate group) (Thimet 15G) (lettuce only) at 7.25 kg/ha in the fertilizer band on one or both sides of the row at seeding time, or when transplants are set in the field. See label for directions and cautions.
- Apply disulfoton (organophosphate group) (Di-Syston 15G) (lettuce only) at 40–75 g/100 m of row at seeding time, in a band on each side of the row. See cautions on the label. Do not use on transplanted lettuce. Use the higher rate on heavy and organic soils.

### *Aphids*

Monitoring for aphids can help determine when and if sprays are required. Check 50–100 plants randomly in the field and measure the percentage of plants infested with aphids. Also note the average number of aphids per plant. Consult the OMAF Factsheet, *Aphids Infesting Lettuce and Celery in Ontario,* Order No. 00-053.

Spray with one of the pesticides recommended in Table 6–41, *Aphid Control Recommendations for Lettuce and Parsley,* above.

### *Cabbage Looper*

This pest is not a common problem in Ontario. If monitoring indicates a need, apply one of the insecticides recommended in Table 6–40, *Lettuce, Endive and Parsley Insect Control Recommendations,* on page 91.

### Tarnished Plant Bug

Romaine lettuce is particularly susceptible to tarnished plant bug. If monitoring indicates a need, apply one of the insecticides recommended in Table 6–40, *Lettuce, Endive and Parsley Insect Control Recommendations*, on page 91.

For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

### Leaf Miners

See the section *Leaf Miners*, on page 66, for leaf miner control recommendations.

### Nematode Control

See the section *Nematodes*, on page 45, for nematode control recommendations.

The booklet *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, Order No. 700, provides a comprehensive guide to IPM on lettuce.

# ONIONS, LEEKS & SHALLOTS

## Cultivars

The varieties listed in Table 6–42, *Suggested Allium Cultivars*, on page 95, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions.

Summer and autumn leek are the two groups of leeks grown in Ontario. Two types of shallots are generally available: the French-Italian (brownish-red skin is the most commonly grown) and the Welsh shallot (green shallot).

Consult seed company representatives for other onion, leek and shallot cultivars currently recommended in your area.

## Seeding and Spacing

### Seeding Rate

| | |
|---|---|
| Dry onions: | 4–4.5 kg/ha (3.5–4 lb/ac) |
| Bunching onions: | up to 7 kg/ha (6 lb/ac) |
| Pickling onions: | 35–45 kg/ha (31–40 lb/ac) |
| Sets: | 70–80 kg/ha (62–71 lb/ac) |

### Spacing

Plant dry onions in rows 35–43 cm apart or 15 and 60 cm apart alternately, with 30–40 plants/m of row.

Plant Spanish transplants 10–12.5 cm apart in the row, in rows 35–43 cm apart or 15 and 60 cm apart alternately.

Seed processing (dicing) onions at a rate to achieve 60–80 onions/m or row.

Plant leeks in rows 60–90 cm apart and 10–15 cm in-row spacing.

## Irrigation

Allium species have shallow, limited root systems. The critical water use period lasts up to and including the bulb formation stage. Do not permit the soil moisture to fall below 50%. The plants should receive 2.5 cm of water a week, either as rainfall or irrigation. Irrigation may not be necessary on deep muck soils. Maintain the water table at 85 cm below the soil surface on muck soils. Irrigation after bulb maturity may not be beneficial and may reduce yield and/or quality.

## Fertility

### Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

**Mineral soils:** Apply up to 110 kg N/ha per season.

**Muck soils:** Apply 90 kg N/ha preplant with one side-dressing of 30 kg N/ha when plants are 8–10 cm high (if rainfall has been above normal or soil temperatures below normal).

On shallow muck soil or soils with a high proportion of mineral soil, use 200 kg/ha monoammonium phosphate (MAP), applied 5–7.5 cm below the seed. Reduce the broadcast fertilizer by 22 kg/ha nitrogen and 96 kg/ha phosphate.

Leeks require higher amounts of nitrogen than onions, normally around 200 kg N/ha, applied in three instalments: one preplant and two side-dressings.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

## Micronutrients

### Copper

Copper deficiency occurs on acid, peat and muck soils. Bulbs show poor-coloured skins. Copper may be mixed with the fertilizer and applied at 14–29 kg copper/ha (12.5–26 lb/ac) on newly cultivated muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck.

### Manganese

Manganese deficiency shows up as a yellowing between the leaf veins. See the section *Manganese*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Table 6–42.
## Suggested Allium Cultivars

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Leek Hybrids** | | | |
| Jolant | Bejo Seeds | 90 | Very productive, mid-term storage. |
| Ramona | Bejo Seeds | 95 | Very productive, autumn type. |
| **Bunching Onions** | | | |
| Ishikara | Takii | | Stiff, upright tops, little to no bulbing. |
| Parade | Bejo Seeds | 75 | Waxy, dark green leaves. |
| **Cooking Onions** | | | |
| Arsenal | Seminis | 95 | Globe shape, good size for maturity, stores well. |
| Corona | Bejo Seeds | 95 | Tolerant to bolt. Large, mid-term storage. |
| Frontier | Takii | early | Average yields, small necks, medium storage. |
| Norstar | Takii | early | Large size, high yield potential, short-term storage. |
| Wolf | Takii | early | Small necks, yields well, short-term storage. |
| Courtland $F_1$ | Bejo Seeds | mid-late | Good skins, mid storage potential, nice necks and good size. |
| Festival $F_1$ | Bejo Seeds | mid-late | Very hard, productive, thick skin, long-term storage. |
| Fortress | Seminis | 105 | Tolerant to pink root. Round globe, dark colour, good neck, long storage. |
| Hamlet | Seminis | 105 | Tolerant to pink root and fusarium basal rot. Good yields, long storage. |
| Millennium | Sunseeds | mid-late | Tolerant to pink root. Large bulbs, light copper colour, good storage. |
| Mustang $F_1$ | Bejo Seeds | mid-late | Large, blocky globe shape, very hard, thick skin, long storage. |
| Prince | Bejo Seeds | 105 | Tolerant to fusarium basal rot. Long storage, very productive. |
| Quantum | Seminis | mid-late | Good yields, glove shape, good colour and short-term storage. |
| Rampart | Seminis | late | Dark skin, firm bulb, long-term storage, strong root system. |
| Ricochet | Seminis | early-mid | Nice round shape, high quality, good size, mid-term storage. |
| Salem | Bejo Seeds | mid-late | High globe shape, large bulbs, dark copper colour, stores well. |
| Tamara | Bejo Seeds | mid-late | Globe shape, good yields and colour, long-term storage. |
| Tribute | Seminis | 105 | Tolerant to bolt, pink root and fusarium basal rot. Globe shape, above-average yields, stores well. |
| Uniglobe 100 | Seminis | mid-late | High globe shape, good size, long-term storage. |
| **Pickling Onions (pearl type)** | | | |
| Snowstorm | Bejo Seeds | 90 | White, crystal wax type. |
| **Red Onions** | | | |
| Mars | Seminis | | Light red, uniform size and shape, high globe, short storage. |
| Mercury | Seminis | mid | Red exterior, good interior colour, good size, globe shape. |
| Red Beauty | Bejo Seeds | 105 | Tolerant to pink root and fusarium basal rot. Large, from transplant. |
| Redwing | Bejo Seeds | 115 | Tolerant to pink root and fusarium basal rot. Large, hard, long storage. |
| Red Zeppelin | Seminis | | Intense red colour, medium-size bulbs, stores well (6 months). |
| **Sets Onions** | | | |
| Jagro | Bejo Seeds | 85 | Very early, stutgarder type. |
| Jet Set | Bejo Seeds | 90 | Perfectly round, long storage. |
| **Spanish Onions** | | | |
| Daytona | Bejo Seeds | 120 | Tolerant to pink root and fusarium basal rot. Jumbo, long storage. |
| Gunnison | Bejo Seeds | 107 | Tolerant to pink root and fusarium basal rot. Large, long storage. |
| Regiment | Seminis | 110 | Tolerant to pink root and fusarium basal rot. Medium-large round bulb. Dark skin. |
| Teton | Seminis | mid | Large size but slightly smaller than Vision and longer storage. |
| Vantage | Seminis | early | Good scale retention, mid-term storage. |
| Vega | Seminis | 117 | Tolerant to pink root and fusarium basal rot. Globe shaped. Excellent size potential. |
| Viceroy | Seminis | 107 | Tolerant to bolt. Good yield, nice colour, some storage potential. |
| Vision | Seminis | late | Excellent size, good firmness, mid-term storage. |
| Yula | Seminis | 103 | Excellent fresh market. |
| **Shallots** | | | |
| Ambition | Bejo Seeds | 100 | Tolerant to pink root. Red brown, long storage. |
| Matador | Bejo Seeds | 100 | Tolerant to pink root. Round red brown, long storage. |
| Prisma | Bejo Seeds | 90 | Tolerant to pink root. Rose colour skin, long storage. |

### Table 6–43.
### Onion Seed Treatments

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Apron XL LS | metalaxyl-m | 20 mL per 100 kg seed | damping-off | For use in commercial seed treatment plants only. |
| Thiram 75 WP | thiram | 65–80 g per 25 kg seed | damping-off | |
| Pro-Gro | carbathiin-thriam | 25 g per 1 kg seed | smut | Pro-gro treated seed may be stored for up to 4 months. |
| Govenor 75 WP | cyromazine | 66.7 g per 1 kg seed | onion maggot | Imported seed only. Only on muck soils. Do not plant treated seed in the same field in consecutive years. |

### *Molybdenum*

Molybdenum deficiency may occur when onions are grown on moderately acid to strongly acid muck soils. A seed treatment has proven beneficial. The treatment is accomplished by dissolving 15 gm of sodium molybdate in 45 mL of water. Spray this solution from an atomizer bottle on 2.3 kg seed spread thinly on a plastic sheet. Do not use excessive water as this can cause the chemical to penetrate the seed embryo and cause injury. Mix the seed thoroughly and let dry. For foliar application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### *Zinc*

Zinc deficiency in onions shows up as a stunting and marked twisting and bending of yellow striped foliage. It occurs mainly with shallow muck soils or where the calcareous subsoils are mixed with the muck. See the section *Zinc*, on page 18, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Disease Management

### *Damping-Off and Root Rot*

Treated seed and use of good sanitation practices during transplant production are the best methods of controlling root rots and damping-off. See Table 6–43, *Onion Seed Treatments*, above, and the section *Vegetable Transplants*, on page 151.

### *Downy Mildew, Botrytis Leaf Blight and Purple Blotch*

Plant sets and mother bulbs as far as possible from onions being grown from seed. These diseases develop in humid weather or when rains and heavy dews occur frequently. Begin spraying when these conditions occur after early June in Southwestern Ontario and after mid-June in the Bradford area. Then spray every 7–10 days with one of the fungicides recommended in Table 6–44, *Onion Disease Control Recommendations*, on page 97.

Disease forecasting models and crop monitoring can greatly improve disease management. Consult the OMAF Factsheet, *Identification of Diseases and Disorders of Onion*, Order No. 95-063. These diseases can also be serious on leeks and shallots, however, no fungicides are currently available.

### *Smut*

To reduce smut infections, steam-pasteurize soil for growing onion transplants or use a sterile soilless mix.

See Table 6–43, *Onion Seed Treatments*, above. An in-furrow granular treatment is recommended where Govenor seed treatment has been used for onion maggot control. See Table 6–44, *Onion Disease Control Recommendations*, on page 97.

The use of a methyl cellulose sticker helps the PRO-GRO remain on the seed and improves smut control. The sticker is available at no charge from the Muck Crops Research Station, Kettleby, Ontario, (905) 775-3783. Thorough mixing of PRO-GRO with the sticker and the seed is essential for good control. Mix until no uncoated seeds can be found. Read label directions.

### *Botrytis Neck Rot and Smudge*

Be certain onions are mature before harvesting. Cure and dry onions properly. Artificial heat during curing may be beneficial. Store under cool, dry conditions. White and Spanish-type onions are more susceptible to these diseases.

### *Basal Rot*

This soil-borne *Fusarium* disease prefers warm soil temperatures and is more common in Southwestern Ontario. Early symptoms include yellowing and tip dieback. As the disease progresses, the plant will collapse, the roots will decay and the basal plate will have a pinkish colour. Secondary rots often follow. Crop rotation and the use of disease-free transplants are recommended.

### Table 6–44.
### Onion Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Downy Mildew, Botrytis Leaf Blight, Purple Blotch** | | | | | | |
| zineb | dithiocarbamate | Zineb 80 W | 2–2.75 kg | 0.8–1.1 kg | 7 | Onions only. |
| mancozeb | dithiocarbamate | Dithane DG | 2.25–3.25 kg | 0.9–1.3 kg | 10 | Labelled for dry onions only. |
| | | Manzate DF | 2.25–3.25 kg | 0.9–1.3 kg | 10 | |
| | | Penncozeb 80 WP | 2.25–3.25 kg | 0.9–1.3 kg | 10 | |
| iprodione | dicarboximide | Rovral[2] | 0.75 kg | 0.3 kg | 15 | Onions only. |
| chlorothalonil | chloronitrile | Bravo 500 | 2.4–4.8 L | 0.96–1.92 L | 7 | Dry bulb. Botrytis leaf blight only. Maximum 3 applications per year. |
| | | | | | 14 | Green bunching. Botrytis leaf blight only. Maximum 5 applications per year. |
| metalaxyl-m/ mancozeb | acylamine & dithiocarbamate | Ridomil Gold MZ 68 WP | 2.5 kg | 1 kg | 7 | Onions only. For downy mildew only. Apply before first outbreak of disease. |
| fosetyl-al | phosphonate | Aliette 80 WDG | 2.8 kg | 1.12 kg | 7 | For downy mildew and purple blotch on onions only. Maximum 5 applications per year. 12-hr re-entry period. |
| **Smut** | | | | | | |
| mancozeb | dithiocarbamate | Dithane DG | 4.4–8.8 kg | 1.76–3.5 kg | 100 | Apply in furrow at seeding time. Use high rate only where smut pressure is high. |

[1] DHI = Days to Harvest Interval.

[2] Rovral when tank-mixed with label rates of maneb or mancozeb will control botrytis leaf blight and downy mildew. Apply on a preventative basis. This tank-mix combination will help reduce the chance of resistance to Rovral.

### *White Rot*

Onion white rot disease is a serious threat to allium production if present. The fungus survives as sclerotia in the soil for long periods. Long-term rotation with carrots, lettuce, potatoes or other crops not related to the onion family is recommended. Rotations of 10–20 years may not reduce the population of white rot in heavily infested soil.

Flooding fields in the fall, winter or spring may reduce white rot. The longer the field is flooded, the more effective the treatment will be. Solarization (covering moist soil with clear plastics) can also reduce white rot in fields with a moderate infestation.

Sanitation is extremely important in preventing the spread of this disease. Wash down machinery after it has been used in an infested field. Avoid cultivation practices that can spread contaminated soil from one area to the rest of the field. Dispose of cull onions in a sanitary landfill or bury away from areas of onion production. Pallet boxes that have been used to hold contaminated soil or diseased onions may also be a source of disease and should be cleaned or destroyed.

**For more information on sanitation, see the section *Storage Sanitation*, on page 38.**

### *Pink Root*

This soil-borne disease rarely causes severe damage but may reduce bulb size or stunt growth especially in drier areas of the field. The roots turn pink or maroon when infected. Long rotations, good nutrition and irrigation may be helpful.

### *Leek Rust*

Rust is a fungal disease that occasionally attacks leeks. Rust-coloured spores on the upper and lower leaf surfaces are characteristic symptoms.

### *Bacterial Diseases*

There are at least three different diseases of onions caused by bacteria; these are soft rot, slippery skin and sour skin. The bacteria that cause slippery skin and sour skin can enter the onion through wounds on the leaves and when heavy irrigation or rainfall results in water standing in the leaf axils and neck. Any of these bacteria can enter the bulb when the leaves wither after windrowing or through injuries that occur at harvest.

Soft rot often occurs when bulbs are damaged by the onion maggot or by other bulb diseases. To reduce bacterial diseases, control the onion maggot, do not overirrigate and avoid damaging the onions at harvest. Let the

## Table 6–45.
## Onion and Leek Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Onion Maggot** | | | | | | |
| **Soil treatment (in-furrow granular)[2]** | | | | | | |
| chlorpyrifos[3] | organophosphate | Lorsban 15 G[3] | 8–16 kg | 3.2–6.4 kg | 109 | Dry onions only. |
| | | | | | 97 | Pickling onions only. |
| | | Pyrifos 15 G[3] | 8–16 kg | 3.2–6.4 kg | 109 | Dry onions only. |
| | | | | | 97 | Pickling onions only. |
| **Sprays for onion maggot flies** | | | | | | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 175 mL | 70 mL | 3 | |
| | | Cymbush 250 EC | 280 mL | 112 mL | 3 | |
| diazinon | organophosphate | Diazinon 50 WP | 1.1 kg | 0.44 kg | 10 | |
| | | Diazinon 500 EC | 1.1 L | 0.44 kg | 10 | |
| | | DZN 600 EW | 915 mL | 366 mL | 10 | |
| parathion | organophosphate | Parathion 960 EC | 225–375 mL | 90–150 mL | 21 | 7-day re-entry period. |
| naled | organophosphate | Dibrom EC | 550 mL | 220 mL | 4 | |
| **Thrips** | | | | | | |
| cypermethrin | pyrethroid | Cymbush 250 EC | 280 mL | 112 mL | 3 | Maximum 3 applications per year. |
| naled | organophosphate | Dibrom | 550 mL | 220 mL | 4 | |
| deltamethrin | pyrethroid | Decis 5 EC | 200 mL | 80 mL | 5 | Maximum 1 application per year. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 188 mL | 75.2 mL | 14 | Maximum 3 applications per year. 24-hr re-entry period. |
| **Cutworms** | | | | | | |
| chlopyrifos | organophosphate | Lorsban 4E | 2.4–4.8 L | 0.96–1.92 L | 60 | Dry onions only. |
| | | Pyrinex 480 EC | 2.4–4.8 L | 0.96–1.92 L | 60 | |
| permethrin | pyrethroid | Pounce | 180–390 mL | 72–156 mL | | Apply up to the 5-leaf stage. Do not disturb soil for 5 days after treating. Use high rate on muck soils. |
| cypermethrin | pyrethroid | Ripcord 400 EC | 175 mL | 70 mL | 21 | Do not disturb soil for 5 days after treating. |

[1] DHI = Days to Harvest Interval.
[2] Refer to the label for spacing and planter specifications.
[3] Resistance to these insecticides has been observed in Ontario muck soils.

onions mature properly before harvest, then cure and dry them rapidly.

Consult the OMAF Factsheet, *Identification of Diseases and Disorders of Onion,* Order No. 95-063.

## Insect Management

### *Onion Maggot*

Seed treatment or proper placement of granular insecticides at the correct rate is the key to onion maggot control. If difficulties are encountered with the granular application, sprays to kill the flies may reduce their numbers. However, evidence suggests that sprays for flies do little to reduce overall damage from maggots in cooking onions and Spanish onions.

See Table 6–43, *Onion Seed Treatments,* on page 96, for a list of available seed treatment options. Soil and foliar control options are outlined in Table 6–45, *Onion and Leek Insect Control Recommendations,* above.

Onions left in the field after harvest are a major source of overwintering onion maggot. This is especially true following early harvest of Dutch sets and pickling onions. Prevent all regrowth and rougue out all volunteer onions early in the season. Incorporate residue immediately after harvest.

For more information, consult the OMAF Factsheet, *Onion Maggot Control,* Order No. 00-017.

### *Thrips*

Monitoring greatly improves the management of thrips on onions. First, estimate the average leaf stage of the crop, then check at least 50–100 plants randomly in the field and record the average number of thrips per plant. Divide by the leaf stage to give the number of thrips per leaf.

Thresholds for green onions and Spanish onions (1 thrips/leaf) are lower than those for cooking onions and leeks (3 thrips/leaf).

**Note:** Some producers and researchers believe the threshold of 3 thrips/leaf for onions and leeks is too high, resulting in unacceptable levels of damage.

Evidence suggests that thrips may develop high levels of resistance in onion fields where repeated use of insecticides occur. Rotate between chemical groups where possible. Hot, dry weather favours thrips infestations. Water volume, coverage and timing are critical. Consult the OMAF Factsheet, *Thrips on Onions and Cabbage*, Order No. 99-027.

### *Cutworms*

Cutworms are an occasional pest of onions in Ontario. If monitoring indicates a problem, see Table 6–45, *Onion and Leek Insect Control Recommendations*, on page 98.

**The booklet *IPM For Onions, Carrots, Celery and Lettuce in Ontario*, Order No. 700, provides a comprehensive guide to IPM for onions.**

## Nematode Control

See the section *Nematodes*, on page 45, for nematode control recommendations.

## Sprout Inhibition

The use of maleic hydrazide (Royal MH 60) sprays will improve the storage life and quality of onions by inhibiting sprouting in storage. Short-storage-life cultivars do not benefit from maleic hydrazide sprays.

Apply at a rate of 3.75 kg in a minimum of 300 L of water/ha for ground equipment or a minimum of 100 L of water for aerial equipment. To obtain maximum benefit, spray when about 50% of the onion tops have fallen and each plant has 5–8 green leaves. This will occur about 10–14 days before harvest. Earlier application may result in spongy, hollow-necked bulbs.

Consult the OMAF Factsheet, *Leek Production*, Order No. 91-004, for more information on leeks.

**How do onions respond to micronutrient fertilizers?**
**See the section *Micronutrients*, on page 16.**

# PARSNIPS

## Cultivars

The varieties listed in Table 6–46, *Suggested Parsnip Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Seeding and Spacing

Parsnips are a long-season crop (100–130 days to maturity), so the seed must be sown as early as possible. Always use seed produced the preceding year. Parsnip seed is slow to germinate, especially in dry, cool soils. Poor stands occur if the soil surface becomes baked or crusted before the seedlings emerge.

| | |
|---|---|
| **Rate:** | 3–5.5 kg/ha (2.7–4.9 lb/ac) |
| **Depth:** | 6–20 mm (<1 in.) |
| **Row Spacing:** | 45–75 cm (18–30 in.) depending on machinery used in cultivation |
| **Thinning:** | Thin seedlings 3–6 cm (1.2–2.4 in.) in the row. On muck soils, adjust seeders to ensure a stand of 16–33 plants/m of row. |

## Soil

Parsnips require deep, loose, fertile soils, preferably a well-drained, warm, sandy loam. Well-drained muck soils are also suitable. The desired pH is about 6.5.

## Fertility

Fertilizer requirements are the same as for carrots. (See *Cucurbits*, on page 77.) For more details, consult the OMAF Factsheet, *Commercial Parsnip Production in Ontario*, Order No. 81-056.

## Disease Management

### *Itersonilia Canker and Leaf Spot*

High ridging to cover the shoulder of the roots is helpful.

**Table 6–46.**
**Suggested Parsnip Cultivars**

| Cultivar | Maturity (days) | Notes |
|---|---|---|
| All-American | early | Moderately resistant to phoma canker. Smooth, white slim roots. Extra sweet when dug after frost in the fall or early spring. Similar to Hollow Crown, but earlier. |
| Arrow | 110 | Resistant to phoma canker. Long, smooth, white tapered roots. Good yielder and stores well. |
| Harris Model | | Susceptible to phoma canker. |
| Hollow Crown Improved | | Moderately resistant to phoma canker. Wedge-shaped, smooth white roots with fine texture, short tops. |
| Javelin | | Description not available, see seed catalogues. |

### *Phoma Canker and Leaf Spot*

Harvest before maximum root and shoulder development. Rotate with other crops. Removal of crop refuse will help control the disease. See Table 6–47, *Parsnip Disease and Insect Control Recommendations*, below. For more details, consult the OMAF Factsheet, *Phoma Canker of Parsnip*, Order No. 87-041.

## Insect Management

### *Carrot Rust Fly*

See the section *Carrot Rust Fly*, on page 61. If monitoring indicates a need, apply as directed in Table 6–47, below.

## Root-Knot Nematode Control

See the section *Nematodes*, on page 45.

> ***Caution:*** Some individuals may be sensitive to the natural chemicals found in parsnip foliage. The level of these substances increases if parsnips are diseased. Using rubber gloves when handling parsnip foliage and leg protection when walking in the field will prevent the development of skin rashes.

**Table 6–47.**
**Parsnip Disease and Insect Control Recommendations**

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] |
|---|---|---|---|---|---|
| **Phoma Canker and Leaf Spot** | | | | | |
| chlorothalonil | chloronitrile | Bravo 500 | 2.8 L | 1.12 L | 7 |
| **Carrot Rust Fly** | | | | | |
| diazinon | organophosphate | Diazinon 500 EC | 1.1 L | 0.44 kg | 10 |
| | | Diazinon 50 WP | 1.1 kg | 0.44 kg | 10 |
| | | DZN 600 EW | 915 mL | 366 mL | 10 |

[1] DHI = Days to Harvest Interval

# PEAS

## Cultivars

The varieties listed in Table 6–48, *Suggested Pea Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under Ontario growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Seeding

| | |
|---|---|
| **Row Spacing:** | 15–20 cm (6–8 in.) |
| **In-Row Spacing:** | 4–5 cm (1.5–2 in.) |
| **Rate:** | 100–300 kg/ha (90–270 lb/ac) depending on seed size and percentage of germination. |
| **Depth:** | 2.5–5 cm (1–2 in.). Plant into moisture. |
| **Date:** | As early as possible or based on processor recommendations. |

## Fertility

### Nitrogen

Where phosphate and potash are required, 15 kg nitrogen/ha is recommended at seeding. If no phosphate and potash are required, the nitrogen may be omitted.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting. Do not drill fertilizer with the seed.

**Table 6–48.**
**Suggested Pea Cultivars**

| **Fresh Market** | | |
|---|---|---|
| Sugar Snap types | Little Marvel | |
| Progress types | Utrillo | Knight |
| **Processing** | As recommended by processors | |

## Disease Management

### Root Rot, Wilt and Near-Wilt

Follow a 4-year rotation and other good management practices such as:

- Select and plant only in well-drained fields.
- Minimize soil compaction.
- Use a seed treatment recommended in Table 6–49, *Pea Seed Treatments*, below.
- Work fields immediately after harvest.
- Plant a green-manure crop such as oats, sorghum-sudan grass or fall rye.

**Table 6–49.**
**Pea Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Agrox B-3 | diazinon-lindane-captan | 80 g per 25 kg of seed | seed and root maggots, wireworms, seed decay and damping-off | Do not use on seed already treated with an insecticide. |
| Agrox D-L plus | diazinon-lindane-captan | 50 g per 25 kg seed | seed and root maggots, wireworms, seed decay and damping-off | Use on seed previously treated with captan or thiram.<br>Do not use on seed already treated with an insecticide. |
| DLC | diazinon-lindane-captan | 50 g per 22.7 kg seed | seed maggots, wireworms and seed rot | Use on seed previously treated with captan or thiram. |
| Apron XL LS | metalaxyl-m | 20–40 mL per 100 kg seed | damping-off and root rot | For use in commercial seed treatment plants only. |
| Captan FL | captan | 70 mL per 25 kg seed | seed decay, damping-off and root rot | For use in commercial seed treatment plants only. |
| Thiram 75 WP | thiram | 25–35 g per 25 kg seed | seed decay and damping-off | Do not feed treated clippings to livestock. |

### Table 6–50.
### Pea Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Aphids** | | | | | | |
| dimethoate | organophosphate | Cygon 480 E | 275–425 mL | 110–170 mL | 3 | Do not feed or graze vines within 21 days of last application. |
| | | Lagon 480 E | 275–425 mL | 110–170 mL | 3 | |
| malathion | organophosphate | Malathion 25 W | 4.25 kg | 1.7 kg | 3 | |
| | | Malathion 500 E | 2.25 L | 0.9 kg | 3 | |
| parathion | organophosphate | Parathion 960 EC | 225–450 mL | 90–180 mL | 14 | Do not permit animals to feed or graze within 15 days of last application.<br>7-day re-entry period. |
| pirimicarb | carbamate | Pirimor 50 DF | 150–275 g | 60–110 g | 6 | |
| naled | organophosphate | Dibrom | 1.1–2.2 L | 0.44–0.88 L | 4 | Processing only. |
| methomyl | carbamate | Lannate SP | 51 g | 20.4 g | 1 | 24-hr re-entry period. |
| endosulfan | chlorinated cyclodiene | Thiodan 4EC | 1.5–2.0 L | 0.6–0.8 L | 7 | Processing only.<br>Maximum 2 applications per year. |
| | | Thionex 50 WP | 1.1–1.75 kg | 0.44–0.7 kg | 7 | Processing only.<br>Maximum 2 applications per year. |
| **Cutworms** | | | | | | |
| permethrin | pyrethroid | Pounce | 180–390 mL | 72–156 mL | | Apply up to 5-leaf stage. Use high rates on large cutworms. Do not disturb soil for 5 days after treating. |

[1] DHI = Days to Harvest Interval.

## Insect Management

### *Seedcorn Maggot, Wireworm and Seed Decay*

Seedcorn maggot flies are attracted to fresh manure, and rotting organic matter attracts seedcorn maggot flies in the early spring. Incorporate manure promptly to discourage egg-laying. Wireworms are most likely to be a problem for the first 2 years following sod.

Use fungicide-treated seed to minimize damping-off. Rotate peas with non-leguminous crops and ensure good drainage in the field. See Table 6–49, *Pea Seed Treatments*, on page 101.

### *Pea Aphid*

This aphid is usually more abundant when peas are grown adjacent to clover or alfalfa. See Table 6–50, *Pea Insect Control Recommendations*, above.

### *Cutworms*

If cutworms are a problem, see Table 6–50, above. Chemical controls are most effective if applied to moist soils in the early evening. For more information, see the section *Cutworms*, on page 44.

**Which crops are the most effective at scavenging residual nitrogen after the pea crop? See Table 3–2, *Characteristics of Cover Crops Grown in Ontario*, on page 25.**

# PEPPERS

## Cultivars

The cultivars listed in Table 6–51, *Suggested Pepper Cultivars*, below, highlight some of the disease-resistance traits available on the market. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

## Transplants

Two hundred grams of seed should produce enough transplants for a hectare. For more information, see the section *Vegetable Transplants*, on page 151.

## Plant Spacing

A standard planting arrangement for pepper crops is single rows with 1.0 m (3 ft) between rows and 45 cm (17 in.) between plants within the row (9,000 plants/ac). Some early, small-plant-type varieties may be planted at 1 m (3 ft) between rows and 30 cm (12 in.) between plants.

Peppers may also be planted on twin rows at 1.5 m (5 ft) centres, with 45 cm (17 in.) between the twin rows, and 45 cm (17 in.) between plants within the row.

## Plasticulture

Research has demonstrated that the use of plasticulture (plastic mulches, row covers and drip irrigation) can improve the production of peppers. Since these practices are relatively expensive, they are likely more suitable for fresh-market pepper production. Black plastic mulch is recommended for peppers because it warms the soil, retains moisture and controls weed growth. Twin row culture is recommended on plastic mulch. For more information, see the section *Plasticulture*, on page 33.

Earlier production of peppers may be achieved by planting 10–14 days earlier than normal and covering the crop with a white plastic row cover. This cover should be opened for ventilation when the temperature inside reaches 35°C or higher. The cover should be removed in early June or whenever conditions are favourable for good growth.

**Table 6–51.**
**Suggested Pepper Cultivars**

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Bell** | | | |
| Boynton Bell | Harris-Moran | 65–75 | Green to red. Tolerant to bacterial leafspot (races 1, 2, 3). |
| Enterprize | Rupp | 71 | Green to red. Tolerant to bacterial leafspot (races 1, 2, 3) and tobacco mosaic virus. |
| Ironsides X3R | Seedway,<br>Rupp | 67 | Green to red. Tolerant to bacterial leafspot (races 1, 2, 3). |
| Karma | Harris-Moran | 55–60 | Green to red. Resistant to tobacco mosaic virus. |
| King Arthur | Rupp | 68 | Green to red. Tolerant to bacterial leafspot (race 2). Tolerant to cucumber, pepper and tobacco mosaic viruses and tobacco etch virus. |
| 4 Star | Rogers,<br>Rupp | 75 | Green to red. Tolerant to bacterial leafspot (races 1, 2, 3), tobacco etch, and pepper and tobacco mosaic viruses. |
| Peninsula | Harris-Moran | 70–80 | Green to red. Tolerant to bacterial leafspot (races 1, 2, 3, 5) and tobacco mosaic virus. |
| Conquest | Harris-Moran | 65–70 | Red to green. Tolerant to phytophthora and cucumber mosaic virus. Resistant to pepper mosaic virus and potato Y. |
| Early Sunsation | Seedway,<br>Rupp,<br>Norseco | 69–70 | Green to yellow. Tolerant to bacterial leafspot (races 1, 2, 3) and tobacco mosaic virus. |
| **Hot Banana** | | | |
| Volcano | Seedway | 63 | Tolerant to tobacco mosaic virus. |
| **Pimento** | | | |
| Super Red Pimento | Stokes | 70 | Tolerant to tobacco mosaic virus. |
| **Processing** | As recommended by processor | | |

## Fertility

### Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

Apply up to 70 kg N/ha. Broadcast 35 kg N/ha and all of the phosphate and potash required before planting and work in. The remainder of the nitrogen should be side-dressed after first fruit set, if required.

For fertigation rates, see the section *Fertigation*, on page 36.

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

### Starter Solution

At transplanting, apply a starter solution high in phosphorus such as 1 L of 10-34-0 per 100 L of water or 1 L of 6-24-6 per 75 L of water. Under high temperature conditions or in dry sandy soils, reduce the amount of fertilizer by half but continue to use the same volume of water. This will reduce the risk of crop injury under these growing conditions.

## Disease Management

### Damping-Off

Sow and transplant in a sterilized medium. Seed treated with thiram is less susceptible to seedling blight and damping-off. Use 90 g of Thiram 75 WP per 25 kg of seed. For more information, see the section *Damping-Off of Seedlings*, on page 44.

### Bacterial Spot

Bacterial spot is the major bacterial disease of peppers in Ontario. Many of the same strains that infect tomatoes also infect peppers. Hot-water- or acid-treated seed is the best method of controlling bacterial spot. (See the section *Hot-Water Treatment*, on page 152.)

Lesions start out on the leaves as small, water-soaked spots that later become large, irregular necrotic areas with a pale tan central area and dark edges. The centre of the spot may drop out, giving leaves a "shot-hole" or ragged appearance. As the disease progresses, an irregular blighting may be seen throughout the plant. In severe infections, leaves may turn yellow and drop. On fruit, the bacteria initially causes green, circular, slightly raised lesions, which later become brown and scabby.

It is not possible to completely control this disease with chemical sprays. A reduction in the number of lesions may be achieved through the application of copper bactericides. In periods of extended wet weather and extensive disease pressures, control using copper materials may not be satisfactory. Use one of the fungicides recommended in Table 6–52, *Pepper Disease and Insect Control Recommendations*, on page 105.

As the pathogen can be seed-borne, ensure that seed and transplants are disease-free. Use a minimum 2-year rotation away from tomato and pepper crops. Some of the varieties listed in Table 6–51, *Suggested Pepper Cultivars*, on page 103, have tolerance to bacterial spot races 1, 2 and 3.

### Virus Diseases (CuMV, TSWV)

Aphids may vector virus diseases such as cucumber mosaic virus (CuMV) to peppers. Monitor and control aphids regularly (see the section *Aphids*, on page 104).

The Western flower thrips (WFT) may occasionally vector the tomato spotted wilt virus (TSWV) to field peppers. The WFT is a small (1–2 mm) insect that can easily be confused with onion thrips. For more information, consult the OMAF Factsheet, *Pest Management of Thrips on Greenhouse Vegetables*, Order No. 94-023.

Other viruses may affect peppers but are not common in Ontario. These include alfalfa mosaic, potato virus Y and tobacco etch. Certain weed species are alternative hosts for some pepper viruses, so controlling weeds within the crop and in field borders may reduce sources of infection.

### Verticillium Wilt

Grow seedlings in sterilized soil. Fumigation may be necessary if field soil populations are high. Crop rotation with non-host crops is recommended. The incidence of wilt may be higher following peppers, tomatoes, eggplant, potatoes, strawberries and raspberries. See the section *Crop Rotation for Control of Diseases*, on page 43.

## Insect Management

### Aphids

Natural predators such as lady beetles, spiders, lacewings, and parasites usually control aphids. Continuous use of broad-spectrum insecticides may disrupt beneficial pop-

### Table 6–52.
### Pepper Disease and Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Bacterial Leaf Spot** | | | | | | |
| copper hydroxide | inorganic | Parasol | 2.25–3.25 kg | 0.9–1.3 kg | 1 | |
| | | Kocide 101 WP | 2.25–3.25 kg | 0.9–1.3 kg | 1 | |
| copper sulfate | inorganic | Copper 53 W | 4 kg | 1.6 kg | 1 | |
| **Aphids** | | | | | | |
| pirimicarb | carbamate | Pirimor 50 DF | 275–550 g | 110–220 g | 3 | |
| dimethoate | organophosphate | Cygon 480 E | 0.7–1.0 L | 0.28–0.4 L | 3 | |
| | | Lagon 480 E | 0.7–1.0 L | 0.28–0.4 L | 3 | |
| diazinon[2] | organophosphate | Diazinon 50 WP | 1 kg | 0.4 kg | 5 | |
| | | DZN 600 EW | 460–915 mL | 184–366 mL | 5 | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.0–2.25 kg | 0.4–0.9 kg | 2 | |
| | | Thiodan 4 EC | 1.5–2.5 L | 0.6–1.0 L | 2 | |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 7 | |
| acephate | organophosphate | Orthene SP | 750 g | 300 g | 7 | Green peach aphid only. |
| **European Corn Borer** | | | | | | |
| deltamethrin | pyrethroid | Decis 5 EC | 250–300 mL | 100–120 mL | 3 | Maximum 3 applications per year. |
| permethrin | pyrethroid | Pounce 384 EC | 180 mL | 72 mL | 1 | |
| carbofuran | carbamate | Furadan 480 F | 1.1 L | 0.44 L | 3 | 48-hr re-entry period.<br>Maximum 3 applications per year. |
| carbaryl | carbamate | Sevin XLR plus | 2.5–5.25 L | 1.0–2.1 L | 2 | In areas where corn borer has been a problem, spray every 4 days. |
| acephate | organophosphate | Orthene SP | 1.1 kg | 0.44 kg | 7 | Do not use more than 4 applications/ season. |
| **Pepper Maggot** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.1 kg | 0.44 kg | 2 | |
| | | Thiodan 4 EC | 1.5 L | 0.6 L | 2 | |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 7 | |
| malathion | organophosphate | Malathion 500 E | 1.25–2.75 L | 0.5–1.1 L | 3 | |
| dimethoate | organophosphate | Cygon 480 E | 0.7–1.0 L | 0.28–0.4 L | 3 | |
| | | Lagon 480 E | 0.7–1.0 L | 0.28–0.4 L | 3 | |
| acephate | organophosphate | Orthene SP | 0.75 kg | 0.3 kg | 7 | Maximum 4 applications per year. |
| **Cutworms** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.2–4.2 L | 0.48–1.68 L | 40 | |
| | | Pyrinex 480 EC | 1.2–4.2 L | 0.48–1.68 L | 40 | |
| permethrin | pyrethroid | Pounce | 180–390 mL | 72–156 mL | 1 | Use high rates on large larvae.<br>Do not disturb soil for 5 days after treating. |

[1] DHI = Days to Harvest Interval.

[2] Control of aphids with diazinon has been inconsistent in many areas.

ulations, resulting in aphid resurgence. Examine the undersides of leaves on 50–100 plants. No threshold is established, but more than 10 per leaf could be considered a potentially damaging level. If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–52, *Pepper Disease and Insect Control Recommendations*, above.

Insecticide sprays are not effective in controlling the spread of viruses by aphids, as aphids transmit the virus on their first feeding on the plant, before the insecticide can take effect.

### Tarnished Plant Bug

Tarnished plant bugs feed on the flower buds of peppers, causing blossom drop and reducing fruit set. They may also pierce the fruit when feeding, causing indentations and yellowing of the flesh, and allowing rot organisms to invade the site. For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

### European Corn Borer

The second generation of European corn borer can be a serious pest of peppers. In Southwestern Ontario, this usually begins during late July. Peppers are susceptible to corn borer attack when the fruit are the size of walnuts (3 cm in diameter) and must be protected from then until harvest if corn borers are present. Use pheromone traps to monitor adult flight activity, or scout fields for egg masses and feeding activity.

For effective chemical control, thorough distribution of spray material is required. Solid- or hollow-cone nozzles on drop pipes provide improved coverage. Use one of the pesticides recommended in Table 6–52, *Pepper Disease and Insect Control Recommendations*, on page 105.

For more information, consult the OMAF Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

### Pepper Maggot

In areas where pepper maggot is a problem and monitoring indicates a need, apply 4 sprays at 7-day intervals, starting the last week of June or first week of July, using one of the pesticides recommended in Table 6–52, *Pepper Disease and Insect Control Recommendations*, on page 105. The presence of adults can be detected using yellow sticky traps baited with a vial of ammonia. Sampling for numbers must be done visually or with a sweep net.

### Cutworms

Apply controls listed in Table 6–52, *Pepper Disease and Insect Control Recommendations*, on page 105, only when monitoring indicates a problem. Most cutworms hide in the soil during the day and emerge to feed at night. Chemical controls are most effective if applied to moist soil in the early evening. Consult the section *Cutworms*, on page 44, for cutworm management recommendations.

### Potato Leafhopper

Potato leafhopper is an unusual and sporadic pest of peppers. Damage to leaf margins appearing as leaf scorch may be observed.

## Nematode Control

See the section *Nematodes*, on page 45.

**For a list of crop zones and planting date guidelines, see the section *Climate Zones and Planting Dates*, on page 29.**

# POTATOES

Table 6–53, *Main Potato Cultivars Grown in Ontario and Their Uses*, below, lists potato cultivars in order of maturity.

## Cultivar Descriptions

### *Tablestock*

**Eramosa:** Very early maturity but better planted after the soil reaches 10°C as it emerges slowly; smooth, round-elongated, flattish tubers with good flavour and quality; sets and sizes evenly; vines are compact and determinate (just live a certain number of days and then die naturally), sets very few flowers; tuber skin is attractive; moderately susceptible to scab and virus Y; and very prone to developing silver scurf in storage; not prone to oversizing and has some field tolerance to leaf roll; seed should be well-warmed or chitted prior to planting. Cut seed should be held to suberize (form a callus) at least one week before planting.

**Envol:** Very early maturing, ready about 7 days earlier than Superior. Nice determinate vine, attractive tuber skin that does not net over like mature Superior does. Susceptible to scab. Yield potential is lower than Superior.

**Jemseg:** Very early maturity but better chitted or planted once the soil reaches 10°C; smooth, blocky tubers; good yield; early-season boiler; tubers oversize very quickly; tubers allowed to oversize usually develop hollow heart; not a storage potato; immune to virus X; resistant to viruses Y and S; moderately resistant to common scab; susceptible to leaf roll, verticillium wilt and fusarium storage rot; cut seed should be held and suberized before planting. Due to poor eye distribution, large seed tubers (over 250 g) are best cut by hand to avoid poor stands from blind seed pieces.

**Superior:** Ontario's most popular early potato. Fairly smooth; high yield potential. Stress (drought or disease) reduces yields substantially; scab tolerance is good but is very susceptible to verticillium wilt, root lesion nematode and early dying. Leaves roll upward under stress conditions. Low eye dominance makes it well adapted to early planting.

**Adora:** Matures about one week later than Superior. Tubers are oblong, light yellow, smooth skin, pale yellow flesh. Very low dry matter content. Susceptible to scab. Medium yield.

**Norland:** Early red-skin. Very susceptible to air pollution and moisture stress. Tolerant to common scab. Avoid the herbicide metribuzin post-emergence. Tubers are smooth, oblong, slightly flattened with shallow eyes. Red skin colour decreases after tubers mature. Tubers are very susceptible to growth cracks when crop is under sudden growth stress. Dry matter is low. Good storability. Some clones with a darker red colour are now available.

**Table 6–53.**
**Main Potato Cultivars Grown in Ontario and Their Uses**
Listed in order of maturity.

| **Table Stock** | | **Dual Purpose** | |
|---|---|---|---|
| Eramosa | chitted for early food terminal sales | Shepody | quality storage tablestock, pre-peel, soups and stews[1] |
| Envol | new! very early | Goldrush | table, baker and pre-peel |
| Jemseg | very early table stock | Kennebec | tablestock, pre-peel, soups and stews |
| Superior | most popular early packer | CalWhite | new! table and pre-peel |
| Norland | early red-skinned market | **Gourmet or Specialty** | |
| Onaway | medium-early, white tablestock for muck soil | CalRed | new! deep red skinned creamers for salad bars |
| Adora | medium-early, light yellow flesh | All Blue | blue skin, blue flesh |
| Yukon Gold | most popular, yellow flesh | German Butterball | dark yellow flesh, excellent flavour |
| Cherokee | very white skin, attracts specialty stores for bulk sales | Banana | small yellow flesh fingerling potato for gourmet dinners |
| Chieftain | most popular, late red skin | | |
| **Chipping** | | | |
| Andover | most popular, early field chipper | | |
| Atlantic | most popular, maincrop field chipper | | |
| Monona | long-term storage chipper | | |
| Snowden | mid-term storage chipper | | |
| Frito Lay varieties | | | |

[1] Soups and stews refers to potatoes usually destined to be used in a diced shape for commercial soup or stew production.

**Onaway:** Performs best when planted very early and is grown primarily for summer tablestock. The vigorous vine will often outyield Superior in stressful seasons. It is a good sizer with white skin and medium eyes but is rougher and has poorer cooking qualities than Superior. It has some tolerance to scab but is prone to blackleg, verticillium wilt, leaf roll and fusarium dry rot.

**Yukon Gold:** Released in 1980 by the Ontario breeding program. Yukon Gold is the most popular golden yellow-fleshed variety in Canada and the U.S. The plant is day neutral, hence adaptable around the world. Tubers are round-elongated, smooth; yellow-fleshed with pink eyes. Quality is excellent for baking, boiling or French fries. The tubers have a distinctive flavour, and the flesh is resistant to after-cook darkening. The tall, upright plants are prone to air pollution but have good tolerance to drought. Maturity is mid-season. Warm the seed for 7–14 days before planting, because this variety has a long dormancy. Plant seed pieces close to avoid oversizing and hollow heart. Yukon Gold emerges rather raggedly and slowly, but experiences a surge of growth later. It may require top-killing before maturity to achieve the medium-sized tubers desired for this premium-priced potato.

**Cherokee:** This variety is a favourite in the Ontario fresh market when washed and offered in bulk. Medium early, medium yield potential and good keeper in storage. Tubers have one of the whitest skins of any variety; medium-deep eyes and good flavour. Misshapen tubers may be a problem under adverse weather conditions; resistant to common scab and some races of late blight; susceptible to verticillium wilt and leaf roll.

**Chieftain:** Most widely grown red-skinned variety in Ontario; fairly smooth, round; red skin, very white-fleshed tubers, sets heavily; high yield; low dry matter; good boiler. It is susceptible to internal heat necrosis, verticillium wilt, blackleg, virus X and Y; moderately resistant to common scab, *Rhizoctonia* and stem end browning; skin must be mature to avoid feathering at harvest; susceptible to shattering under wet soil conditions coupled with wide differences in air and ground temperature. The red skin colour tends to fade or scurf over in some soils, diminishing its appeal for the bright red skin colour the market desires.

### Chipping

**Andover:** Mid-season field chipper with medium yield potential but with high potential for good chip colour with low chip defects, making it highly favoured by processors. The upright vines decline rapidly under heat and drought stress. The margins of the leaflets become brown, roll up; this symptom can be confused with leafhopper damage. This variety is prone to early dying. The seed has a slightly longer dormancy than Superior and should be warmed before cutting, treating and planting.

**Atlantic:** Regarded as a major variety for field chipping. Maincrop maturity; round, smooth; medium-netted tubers; high yield and dry matter, vigorous plant; chips excellent out of the field; seldom used as a storage chipper in Ontario; tolerant to verticillium wilt; resistant to virus X, pink eye, but susceptible to internal heat necrosis in hot soils, hollow heart, fusarium dry rot in storage and post-emergent applications of metribuzin. Moderately susceptible to metribuzin applied preemergent on low organic-matter soils; susceptible to harvest bruising and pressure bruising in storage.

**Monona:** Roundish, white-skinned, medium-eyed tubers, medium to good yield; low in dry matter; chiefly used as a long-term storage chipper; not recommended for table stock; resistant to virus Y and A, and tolerant to verticillium wilt; moderately susceptible to hollow heart and blackleg; requires good storage ventilation.

**Snowden:** Late-maturing medium-term storage chipper and standard for in-plant yield and defect-free chip production; responds to good management (unforgiving if neglected); medium netted round tubers; good-to-high dry matter; deep rooted. It sets tubers deeper and to the edge of hills. It can be a poor sizer, responds to additional nitrogen and should be planted at 30–35 cm within the row. Moderately susceptible to scab (surface and pitted), verticillium wilt, late blight and stress. Care is required at harvest to prevent bruising and black spot. Frying-wise, Snowden recovers from shock better than most chippers.

**Frito Lay varieties:** For information on these chipping varieties, contact the Frito Lay Company.

### Dual Purpose: Pre-Peel and Tablestock

Pre-peel refers to potatoes partially prepared by peeling or shaping in the fresh state for later convenience cooking by institutions or restaurants. Pre-peeled potatoes have a refrigerated life of about a week.

**Shepody:** Medium-late main crop. Most important white flesh variety bred in Canada and the leading storage table stock potato in Ontario; large, oblong, smooth-eyed and smooth-skinned tubers; a late sizer; good-to-medium high yields, although lower performance in very hot growing seasons; excellent baker, boiler and French-frier; good pre-peeler; medium dry matter; moderate resistance to early blight, fusarium dry rot and rhizoctonia; susceptible to common scab, verticillium wilt, late blight and virus Y and S; very susceptible to mild mosaic and postemergent applications of the herbicide metribuzin. Preemergent applications of metribuzin on low organic-matter soils may also cause damage; good resistance to tuber shattering. Maintain aphid control, as Shepody is not totally immune to net necrosis. Does not perform well in the hottest areas of Southwestern Ontario. Sealing soil cracks prior to vine killing reduces tuber greening.

**Goldrush:** Late maturity. Good yield and a medium-sized, shiny-leafed vine. Tubers have golden russet skin and are smooth with very white flesh. Very susceptible to early blight, air pollution and to most potato viruses. The use of year-out seed is not recommended unless a laboratory test indicates that mosaic infection of seed is below the tolerance level. Resistant to hollow heart. Excellent for baking and pre-peel. Tubers have short dormancy and good tolerance to scab. Its very white flesh, texture and excellent flavour make it particularly suitable for restaurants.

**Kennebec:** Heavy, vigorous plant; tubers thin-skinned, sets light and may oversize; plant under close spacing 20–25 cm; very high yield and medium dry matter and good flavour; do not use more than 130 kg of nitrogen; to reduce cullage, top-kill sprays and promote skin set for storage. Tubers green rapidly under light; resistant to virus A and Y, visual field mosaic and drought; very susceptible to verticillium wilt and pink eye; moderately susceptible to common scab, late blight tuber-rot and leaf roll. Kennebec sets higher in the hill, making it more prone to tuber sunburn or frost damage.

**CalWhite:** Very vigorous plants with thick stems with an upright growth habit when young. Tubers are oblong and large, slightly flattened with buff-coloured skin and white flesh. Good yielder, short dormancy and susceptible to heat sprouts under warm soil conditions. Requires good control of aphids because it is susceptible to leaf roll and net necrosis. Susceptible to scab. Sensitive to metribuzin. Plant spacing should be relatively close in order to avoid oversize potatoes that can go hollow. Crop should be monitored closely to time vine killing. It has been observed that tubers reach good size when vines are still vigorous and green.

### *Gourmet or Specialty Market*

**CalRed:** Mid-season to medium-late maturity. Produces a high set of even-sized, small, round, deep-red-skinned tubers. Susceptible to scab. Cream-coloured flesh. Good cooking quality, low boiling sloughing. Good variety for the creamer market. Few culls.

**All Blue:** Mid-late maturity. Blue skin and blue flesh. Prone to scab and silver scurf.

**German Butterball:** Mid-to-late maturity. Oval tubers with dark yellow flesh. High yield. Excellent boiled, mashed and baked.

**Banana:** Late maturity. Fingerling potato (long and thin). Plants with many stems that set numerous smooth yellow skin and yellow flesh tubers. Tubers measure approximately 2.5 cm by 7.5 cm (1 in. by 3 in.). Good yielder. One of the most popular fingerling potatoes, best baked, steamed or in salads.

## Seeding Rate, Spacing and Depth

The amount of seed needed for planting depends mainly on the spacing within the rows and on the characteristics of the variety.

A healthy 2-oz seed piece is considered best to establish a vigorous plant. Plants from seed pieces smaller than 1.5 oz are generally slower to emerge and have less vigour. Small seed pieces are also more likely to decay before the plant becomes established. Seed pieces cut larger than 2 oz result in higher seed costs with little potential benefit.

The distance between rows is usually 90 cm (36 in.).

Seed spacing is based on variety characteristics such as tuber set, resistance to hollow heart and resistance to the development of off-shaped tubers. Wider spacing (30–32 cm or 12–13 in.) is recommended for varieties with heavy tuber set, smooth tubers and resistance to hollow heart and off-shaped tubers. Closer spacing (20–25 cm or 8–10 in.) is recommended for varieties with lower tuber set to reduce the number of oversized tubers.

Seed potatoes are planted near ground level and covered with 5–8 cm (2–3 in.) of soil by the planter.

## Sanitation

The storage area and all potato equipment, including cutting knives and containers, should be completely cleaned before using. Clean out and thoroughly scrub with detergent all machinery, equipment, walls, floors, etc., then use a quaternary ammonium compound labelled for bacterial ring rot control.

Disinfectants are inactivated by organic matter, so are only effective on clean surfaces. The surface should remain wet 20 min after the disinfectant is applied. Cull piles may be buried deeply in marginal land or taken to a sanitary dump site. Exposed cull piles are not desirable, as they are food sources for Colorado potato beetles, maggot flies and inoculum sources of late blight spores. Control vine growth on cull piles with a suitable vine killer.

## Seed Potatoes

Seed potatoes fall into seed classes, as shown in Table 6–54, *Canadian Seed Classes*, right.

## Seed Sources

The availability of seed of new or specialty cultivars can often be limited. To ensure a supply of seed, contract with your seed growers. For information on contracting and seed availability lists, contact the Ontario Seed Potato Growers Association at 109 Hutchinson St., Alliston, Ontario, L0M 1A0 Fax: (705) 435-5661.

## Seed Handling and Management

Plant Elite or Foundation Class seed to reduce leaf-roll, mosaic and bacterial diseases. Inspect seed on arrival for heating, freezing, grade and visual tuber disease. Seed lots can be regraded by your local Agriculture Canada seed potato inspector in some cases. Request for reinspection must be made within two working days of receipt of the seed potatoes.

Request at least two certification tags with each bulk load — one for your bin and one for your files. The tag number gives you direct access to the seed grower. Handle, store and plant the seed carefully. Poor stands and field performance are not always the seed grower's fault. During cutting, discard tubers and seed pieces showing rot.

Pad all seed-handling equipment as you would harvest equipment and reduce drops to less than 15 cm to reduce bruising. Ensure that cutter knives are sharp. As cold storage temperatures make seed tubers more sensitive to bruising, warm seed to at least 5°C prior to handling. Ideally, seed should be around 10°C for cutting. Bruising acts as an entry site for pathogens leading to seed piece decay. Mishandling seed may physiologically age seed, leading to more stems per plant, smaller tubers and more stress susceptibility.

Several physiological factors influence stand, for example, physiological age of seed, apical dominance, eye distribution and variety. "Middle-aged" seed emerges faster than young or excessively old seed. Varieties with strong apical dominance, such as Jemseg and Yukon Gold, will produce uneven stands when using cut seed because of the delay in emergence from non-apical buds.

Varieties with weak apical dominance, such as Superior, produce more uniform stands from cut seed. Eye distribution on seed tubers is important, as some varieties have even eye distribution (Superior) while others have eyes concentrated at the apical end. When cut by machine, the latter varieties produce a large proportion of blind seed pieces. Large tubers accentuate the problem and should be graded out and cut by hand. Check seed coming off the cutter frequently for size, blind pieces and slivers, and adjust if necessary.

### Table 6–54. Canadian Seed Classes

| Class | Field Generation[1] |
|---|---|
| Nuclear | Greenhouse Laboratory |
| Pre Elite | 1 |
| Elite I | 2 |
| Elite II | 3 |
| Elite III | 4 |
| Elite IV | 5 |
| Foundation | 6 |
| Certified | 7 |

[1] Seed drops a class each year in the field if it passes inspection.

The physiological age of seed affects the performance of the crop. The rate of aging depends on cultivar and temperature. Varieties can have short (CalWhite), intermediate (Superior) or long dormancies (Yukon Gold, Jemseg, Eramosa). Long-dormancy types will require more aging than short-dormancy types. The rate of aging also increases with temperature. Old seed is desirable for earlies as it emerges faster and more uniformly, sets and bulks tubers earlier and matures faster than plants from young seed. Old seed is desirable for earlies, seed production and production in short-season areas.

In long-season areas, young seed is desirable for main crops to use the long bulking period. Old seed may result in lower yields of main crops as plants may be more stress prone. If seed is sprouted upon receipt, additional aging may result in excessively aged seed for main crops in long-season areas. Long periods of warming or curing at warm temperatures of such seed may result in excessive aging.

Cut seed not being planted immediately should be given special attention to ensure healing and suberization by:

- forced-air circulation through the shallow pile
- temperatures of 10°C–15°C
- high relative humidity in the air of 90%–95% (prevent free water from forming on tuber surfaces).

Maintain these conditions for 3–4 days. After this, temperature may be lowered, but humidity must be maintained and fans run intermittently.

Cut seed stored in boxes or bags should get the same conditions and be piled to allow good air movement around each container.

Never allow cut seed to stand in the hot sun or in drying wind. This causes minute cracks in the skin that allow bacteria and fungi to establish.

Do not plant seed tubers that have been washed. Do not plant in hot, dry soil or cold, wet soil. Do not plant potatoes immediately after plowing down a heavy green stand of rye or clover.

### *Seed Piece Treatments*

Seed piece decay can be a major problem in some years in most production areas. Serious problems with seed piece decay are often related to adverse weather during the planting season. Fungal seed piece decay is usually caused by several species of the fungus *Fusarium*. These pathogens need wounds to enter the seed piece, and decay is favoured by a wide range of temperature and moisture conditions.

There may be little benefit from seed piece treatments if soil conditions are optimal during planting and crop emergence. However, if unfavourable environmental conditions develop soon after planting, treated seed usually produces a better stand. Because weather conditions are not always optimal at planting and may change afterward, application of a seed treatment is a valuable precautionary measure.

Seed treatments may also help in managing other diseases including rhizoctonia canker, late blight and blackleg.

Mancozeb, the active ingredient of some *Fusarium* seed treatments also protects healthy seed pieces against late blight. The late blight fungus produces spores on cut surfaces of infected tubers in 24 hours. These spores will infect healthy seed pieces. Other seed treatments that do not contain mancozeb (MZ) such as Maxim and Senator do not protect healthy seed against late blight infection.

Mancozeb does not cure existing late blight infections, it only prevents new infections. **It is strongly recommended not to plant seed lots that are known to be infected with late blight.** The risk of disease spread increases with the length of time cut seed lots are held before planting. The longer seed is stored, the greater the risk of late blight infection.

Gypsum-based coatings act as a drying agent but have no insecticidal or fungicidal activity. Seed treatments are usually dusted onto cut seed as it moves along the conveyor. The seed is often then moved through a rotating drum apparatus to distribute the treatment more evenly. It is important to check the applicator often to be certain that the treatment is applied at the labelled rate.

**Table 6–55.**
**Potato Seed Piece Treatment Recommendations**

| Common Name | Group | Trade Name | Rate per 50 kg seed |
|---|---|---|---:|
| thiophanate-methyl | benzimadazole | Senator PSPT | 250 g |
| metiram | dithiocarbamate | Polyram 16 Dust | 225–325 g |
| mancozeb | dithiocarbamate | Tuberseal | 250 g |
| | | Potato ST 16 | 250 g |
| fludioxonil | phenylpyrrole | Maxim PSP[1] | 250 g |

[1] On the varieties Shepody and Atlantic, it has been observed that Maxim treatments may increase the number of stems, leading to smaller tuber size.

Because of the proximity of the cutting and treatment operations, **dust control can be a problem.**

See Table 6–55, *Potato Seed Piece Treatment Recommendations*, above.

Do not plant seed lots that are known to be infected with late blight.

## Chitting or Green Sprouting

This process may be used for limited plantings, where early emergence and yield are important, or in short-season areas. Chitting is the process of aging seed in the light to control sprout growth, resulting in earlier emergence and sizing. Chitting will take several weeks, so plan well ahead of the expected planting date.

Small, whole seed is placed in shallow containers 2–3 tubers deep that allow for air movement and light penetration. Seed can be chitted in a building with fluorescent lights or natural light in a greenhouse. Short, stubby, dark-green spouts are desirable to minimize sprout damage at planting.

Chitting seed in cool temperatures (such as 8°C) under fluorescent light results in shorter sprouts than using warmer temperatures. Seed taken from winter storage of 3°C–4°C will require about 250 degree-days using a 4°C base. For each day, calculate as follows:

$$\text{Degree Day (DD)} = \frac{(\text{Max. Temp.} + \text{Min. Temp.})}{2} - \text{Base Temp}$$

For example, if the maximum temperature is 15°C, the minimum temperature is 5°C, and the base temperature is 4°C:

$$\text{Degree Day (DD)} = \frac{(15 + 5)}{2} - 4 = 6$$

At this rate, it would take approximately 41 days (250 DD ÷ 6) to green sprout the tubers. Green-sprouted tubers should be planted with cup or bell planters to reduce the chances of green-sprout injury. Avoid pick planters. Sized seed will improve the uniformity of emergence.

If a greenhouse is unavailable, seed can be chitted at 20°C in natural shaded light for about 2 weeks with similar results. The same can be accomplished inside a heated building. Higher levels of fluorescent light are required than at cool temperatures. In all cases, provide sufficient humidity to prevent dessication but not enough to stimulate rooting.

## Soil

A soil pH of 6 to 7 is desirable for optimum growth of potatoes. Apply limestone to rotation crops where possible, and in the fall if potatoes follow potatoes.

Soil organic matter can be maintained by use of well-decomposed barnyard manure, grass or legume sod crops, or cover crops. A thick cover crop seeded after early potatoes will reduce soil blowing and fertilizer leaching. Manure should be applied in the fall and incorporated.

## Fertility

### Nitrogen

See Table 6–56, *Nitrogen Recommendations for Potatoes*, right, for nitrogen requirements. If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

If the total nitrogen plus potash applied is over 360 kg/ha, broadcast at least a portion before planting to avoid concentrating the fertilizer band near the seed piece and potato roots. Broadcasting or side-dressing nitrogen after potatoes are 20 cm high is not generally recommended because it may delay maturity.

**Table 6–56.**
**Nitrogen Recommendations for Potatoes**

| Soil Type | Recommended Rate (kg N/ha) | Expected Marketable Yield (t/ha) |
|---|---|---|
| Mineral main crop | 50 | 15 |
| | 75 | 20 |
| | 130 | 25 |
| | 200 | 30+ |
| Mineral early crop | 70 | |
| Muck early and main crop | up to 60 | |

### Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.)

On mineral soils testing medium or low for phosphate, place some or all of the phosphate fertilizer in bands 2.5 cm below and 6 cm to each side of the seed piece at planting time. On muck soils or on mineral soils testing high for phosphate, placement is less critical and fertilizer may be broadcast.

### Plant Analysis

Samples for plant analysis should be taken at early bloom. Take leaf samples from at least 50 plants distributed throughout the area chosen for sampling. Take the fourth leaf from the tip, including the petiole. Sample problem areas separately. See Table 6–57, *Interpretation of Plant Analysis for Potatoes*, on page 113.

Plants suspected of nutrient deficiency should be sampled as soon as the problem appears. Expert help will be required to interpret plant-analysis results when the samples are not taken at early bloom. A soil sample should be taken from the same area and at the same time as a plant sample. For more information on plant analysis, see the section *Plant Analysis*, on page 10.

## Disease Management

Practice a suitable crop rotation to prevent build-up in the soil of organisms causing verticillium wilt, rhizoctonia, common scab and early blight.

### Seed-Piece Decay

See the section *Seed Handling and Management*, on page 110.

*Note:* Seed piece treatments will not control bacteria.

### Table 6–57. Interpretation of Plant Analysis for Potatoes

Values apply to the fourth leaf, including stem, from the growing tip at early bloom.

| Nutrient | Units | Critical Concentration[1] | Maximum Normal Concentration[2] |
|---|---|---|---|
| Nitrogen | % | 2.50 | 3.50 |
| Phosphorus | % | 0.15 | 0.50 |
| Potassium | % | 1.20 | 2.50 |
| Calcium | % | 1.50 | |
| Magnesium | % | 0.10 | 0.60 |
| Sulphur | % | 0.14 | |
| Boron | ppm (ug/g) | 2.0 | 25.0 |
| Copper | ppm | 2.0 | 25.0 |
| Manganese | ppm | 15.0 | 150.0 |
| Zinc | ppm | 14.0 | 70.0 |

[1] Yield loss due to nutrient deficiency is expected with nutrient concentrations at or below the "critical" concentration.

[2] Maximum normal concentrations are more than adequate but do not necessarily cause toxicities.

The leading cause of potato seed piece breakdown after planting is fusarium dry rot. Modern potato handling equipment, such as harvesters, bulk unloaders and bin pilers ensure the *Fusarium* fungus in the soil is mixed thoroughly over the seed tubers at harvest. Initially there may be no visual evidence *Fusarium* is there. A "bag test" is recommended one or two months after storage to assess the *Fusarium* concentration. Select 20 tubers from the face of the pile, cut them in quarters if small or in eighths if larger and drop them in a new 10-lb potato bag. Shake the bag vigorously for a minute to inoculate the freshly cut seed. Fold the paper bag over loosely, place it inside a plastic garbage bag that is also folded over loosely and place it in your basement where the temperature will be 16°C–18°C (60°F–65°F). Let the bag sit for 3–4 weeks. If more than 30% of the seed pieces show visual *Fusarium* infection, there is a potential high incidence of seed piece decay. See Table 6–55, *Potato Seed Piece Treatment Recommendations*, on page 111.

### Rhizoctonia

*Rhizoctonia* can cause severe losses when soil conditions are cold and wet and/or potatoes are grown in short rotations. Symptoms include poor emergence, stem and stolon cankers, aerial tubers, leaf rolling, premature death of plants and tuber malformations.

Usually, on infected plants, a greyish-white mycelium develops on the stems just above the soil line. The black sclerotia or black scurf that develops on tuber surfaces cause serious losses for tablestock growers.

*Rhizoctonia* populations increase in soil where little or no rotation is practised. Planting seed tubers that are heavily infested with sclerotia also favours inoculum build-up in soil.

To reduce the incidence of *Rhizoctonia*, avoid land known to be heavily infested. Rotate the crop with, for example, spring barley on mineral soil or onions on muck soils. See the section *Seed Handling and Management*, on page 110.

### Early Blight

Early blight is a very common fungal disease of potatoes that is more severe when the crop is under stress. The typical symptoms of this disease are dark-brown to black spots with concentric rings. The spots are often irregular in shape. Symptoms develop first on the older leaves of mature plants spreading to the younger leaves under favourable weather conditions.

Begin the fungicide spray program early so that lower plant foliage is well covered. Conditions favourable for disease development are combinations of temperatures between 17°C–24°C and 12 hours of leaf wetness throughout the plant canopy. In addition, stress conditions such as drought, insect damage, air pollution and rapid growth at tuber sizing increase the foliar susceptibility to early blight. Under these conditions, spray intervals should be shortened to 7 days.

### Late Blight

Late blight fungus has the potential to be an extremely destructive disease of potatoes in Ontario. The fungus attacks leaves, stems and tubers. High moisture and cool temperatures favour disease development. Other hosts of the late blight fungus are tomatoes, hairy nightshade, bittersweet and petunia (*Petunia hybride*).

The fungus has two mating types, A1 and A2. A2 is a new, more aggressive mating type of late blight with many strains that have high levels of resistance to Ridomil. The old A1 strain has also developed resistance to Ridomil. Only a laboratory analysis can determine which mating type and strain are infecting a crop. Field identification is limited to "late blight." If the two mating types infect the same potato plant tissue and mate, oospores or sexual spores are produced. Oospores are thick walled, survive in the soil for several years in a dormant state and can initiate late blight infections. In Ontario, the presence of oospores in potato fields has not been detected.

The late blight fungus overwinters in infected cull tubers or seed tubers and initially develops inside the stems and new foliage grown from infected tubers. Temperatures of 12°C–20°C, coupled with foliar wetness for a few hours, could cause sporulation of the fungus from the stomata of infected plants. These spores are dispersed by wind. Farm equipment carrying contaminated plant material can also disseminate the pathogen to healthy fields.

Spores germinate in the presence of free water and penetrate leaves, stems and petioles, initiating new infections.

Disease symptoms develop in about 4 to 6 days after infection. Initial symptoms on leaves are small, light-to-dark green, circular-to-irregular-shaped, water-soaked spots. Later the lesions become grey to tan and are surrounded by a light green halo. The white and fuzzy mycelium of the fungus and spores develop at the edge of the lesions, usually on the underside of leaves. Entire leaves can become blighted as new infections occur and existing lesions coalesce. On petioles and stems, irregular dark brown to black lesions develop. Under humid conditions, the lesions enlarge rapidly and kill the petioles and stems. If no effective fungicides are applied and wet weather prevails, late blight can destroy a potato field in a few days.

Tubers are infected in the potato hill by late blight spores washed by rain from infected foliage into the soil. Tuber infection can occur at any time during the growing season. Tubers are also contaminated with spores of the fungus if they are dug while infected vines still have active lesions with viable spores. The external late blight symptoms on tubers are irregularly shaped, slightly sunken areas of brown to purplish of variable size. Under the skin, a reddish-brown granular dry rot develops that extends into the tuber less than half an inch. Following late blight infection, secondary bacteria infect the tubers. Bacterial soft rot develops rapidly under warm, humid conditions and causes a slimy and foul-smelling rot.

### Management Practices That Reduce the Incidence of Late Blight

- Plant healthy seed. Tagged seed (Elite or Foundation) gives no guarantee it is not carrying late blight.
- Use a seed treatment containing mancozeb.
- Destroy cull piles by burial, chopping, freezing or feeding to livestock prior to new crop emergence. Monitor cull disposal sites and treat emerging sprouts with herbicide.
- Control volunteer potatoes growing in neighbouring fields.
- Create a good hill that ensures good tuber coverage.
- Start a fungicide program early, before row closure. Use protective fungicides (see Table 6–58, *Potato Disease Control Recommendations*, on page 115) and keep all foliage and newly formed leaves covered. It is critical to time the sprays so that the crop is protected before infection periods or periods of wet weather occur. Use of the recommended fungicides may reduce the incidence of tuber blight.
- Control weeds. Weeds growing in the rows increase the humidity within the potato canopy, favouring the development of late blight.
- If possible, irrigate during the day to avoid prolonged periods of wet foliage during the night.
- Scout fields twice a week and pull and bag the first infected plants seen. Mark these areas with a flag and recheck.
- Disc in or top-kill any late blight hot-spots immediately.
- Once the disease has been detected in the field, continuous copper sprays kill the late blight spores on the soil that might otherwise be washed into the tubers.
- Do not irrigate near the end of the season if new outbreaks of late blight are noticed.
- Seal soil cracks to reduce tuber infection.
- Harvest when vines are completely dead, so living spores are not sprinkled on tubers at harvest.
- Sort tubers coming into storage and remove decayed tubers.
- Monitor the storages frequently and look for water condensation on the walls and ceiling. Keeping the temperature and the humidity at the lowest possible levels should reduce the spread of late blight in storage.

**The most effective late blight management program integrates multiple disease management practices and does not rely on a single method.**

**Potato growers can readily integrate most of the above-mentioned cultural practices to keep tuber blight incidence as low as possible.**

**Late blight is a community problem, that is, it is easily spread from farm to farm and over greater distances. Thus, strategies for control of late blight must be used by all growers.**

### *Verticillium Wilt*

This fungal disease has a very wide host range and is very persistent in the soil. In combination with nematodes, verticillium wilt causes premature dieback syndrome. Test soils for *Verticillium* levels (see the section *Nematodes*, on page 45). If *Verticillium* and/or nematode levels are high, row or broadcast fumigation gives a quick fix. Otherwise, incorporate long-term rotations with non-host crops, or plant cereal cover crops after early potato harvests to control weed hosts. Increasing soil tilth promotes stronger, healthier potato roots.

## Table 6–58.
## Potato Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Early and Late Blight Control Scheduled Protectant Program** | | | | | | |
| chlorothalonil | chloronitrile | Bravo 500 | 1.75–2.25 L | 0.7–0.9 L | 1 | Use high rate under severe disease pressure. |
| mancozeb | dithiocarbanate | Manzate DF | 1.1–2.25 kg | 0.44–0.9 kg | 1 | Use higher rates as the crop canopy closes. |
| | | Dithane DG | 1.1–2.25 kg | 0.44–0.9 kg | 1 | |
| | | Penncozeb 75 DF | 1.1–2.25 kg | 0.44–0.9 kg | 1 | |
| metiram | dithiocarbanate | Polyram DF | 1.1–2.25 kg | 0.44–0.9 kg | 1 | |
| propamocarb hydrochloride/ chlorothalonil | carbamate/ chloronitrile | Tattoo C | 2.7 L | 1.08 L | 7 | Apply prior to infection when weather conditions are conducive to late blight development. Repeat at 7–14-day intervals. Maximum 3 applications per year. When applying Tattoo C on the longer spray interval (14 days), alternate with a contact fungicide midway. |
| dimethomorph/ mancozeb | morpholine/ dithiocarbanate | Acrobat MZ | 2.5 kg | 1 kg | 14 | Apply when disease first threatens or when first visible signs occur nearby.<br>Maximum 3 applications per year. |
| zoxamide/ mancozeb | group 22 | Gavel 75 DF | 1.7–2.25 kg | 0.68–0.9 kg | 3 | Begin applications at first sign of disease or when blight is reported in the area.<br>48-hr re-entry period.<br>Maximum 6 applications per year. |
| **Late Blight Control Only** | | | | | | |
| copper hydroxide | inorganic | Kocide 101 WP | 1.1–2.25 kg | 0.44–0.9 kg | 1 | Copper aids in killing late blight spores that fall on the soil before they get washed in to infect tubers. If live spores are suspected at vine killing time, use 3.4 kg/ha of Kocide after top killing as well. Kocide contains copper hydroxide or fixed copper, which does not cause phytotoxicity. |
| | | Kocide DF | 1.1–1.7 kg | 0.44–0.68 kg | | |
| | | Parasol | 1.1–2.5 kg | 0.44–1 kg | | Combine with 1.75 –2.25 kg/ha (0.7–0.9 kg/ ac) mancozeb (80%). |
| copper sulphate | inorganic | Copper 53W | 5.5 kg | 2.2 kg | 1 | Copper sulphate can cause phytotoxicity, especially under hot and humid conditions. Apply close to vine killing time to kill spores of the late blight fungus. |
| copper oxychloride | inorganic | Copper spray | 4 kg | 1.6 kg | 1 | |
| cymoxanil | acetamide | Curzate 60 DF | 225 g | 90 g | 8 | Mix with Manzate 200 DF at 1.6 kg/ha. If seed infection is suspected, spray at 95% crop emergence. 24-hr re-entry period. |
| **Pythium Leak, Pink Rot** | | | | | | |
| metalaxyl-m/ mancozeb | acylamine/ dithiocarbamate | Ridomil Gold MZ 68WP | 2.5 kg | 1 kg | | Mancozeb, the protectant fungicide in this mixture, should also provide protection against early and late blight.<br>Do not use more than 3 times per season. |
| metalaxyl-m/ chlorothalonil | acylamine/ chloronitrile | Ridomil Gold/ Bravo Twin Pak 480/500 | 2.21 L (1 jug/4 ha) | 0.88 L (1 jug/10 ac) | | Do not use more than 3 times per season. |
| **Fusarium Dry Rot** | | | | | | |
| mancozeb | dithiocarbamate | Dithane F45 | 1.58 L per 1,000 kg of seed | | | Apply post-harvest to seed potatoes prior to storage. |

---

[1] DHI = Days to Harvest Interval.

### Pythium Leak

The fungal disease pythium leak is particularly troublesome in immature potatoes harvested under warm conditions. The typical symptom on infected tubers is a cream-to-black watery rot. Water usually drips from diseased tubers. The rotted flesh is clearly demarcated from healthy tissue by a dark boundary line. Tubers are infected through cut surfaces or bruises that occur during harvesting. Serious losses can occur also when tubers are handled roughly, and when crops are stored at high temperatures with poor ventilation. In addition, leak can be a problem on cut seed in the field.

The following management practices should reduce the incidence of leak:

- Minimize mechanical injury to the tubers during digging, grading and storage operations.
- Do not harvest when the weather is too hot.
- Cool tubers dug during warm weather immediately and increase air movement in the storage area.

The fungicides listed in Table 6–58, *Potato Disease Control Recommendations*, on page 115, should reduce the incidence of this disease.

### Pink Rot

Pink rot is caused by a fungus that is related to the late blight fungus. Pink rot causes a soft, spongy rot on tubers. On exposure to the air, the infected flesh develops a pink colour. Internal rot usually begins at the stem end and is creamy or light brown. Wilt symptoms can occur on foliage.

The fungicides listed in Table 6–58, *Potato Disease Control Recommendations*, on page 115, should reduce the incidence of this disease.

### Blackleg

This bacterial disease may be seed-borne and travel up into the shoot early on as the season progresses or it may develop in the vine as stalk rot and go down and infect the daughter tubers. Poor sanitation and seed cutting practices may increase the incidence of this disease. Weather conditions promote or retard blackleg. Where possible, use tolerant varieties that seldom get blackleg or stalk rot, and use higher generation seed.

### Common Scab

Choose tolerant cultivars such as Superior, Cherokee, Onaway and Norland if appropriate. Avoid heavy applications of limestone. Where irrigation is available, maintain high soil moisture for about 4 weeks after tuber setting begins to minimize scab.

Recent research has shown that application of organic amendments reduces the incidence of scab.

### Powdery Scab

Powdery scab is only a problem in Northern Ontario. Plant Elite or Foundation seed. Plant in warm, well-drained soil. Do not plant in fields in which powdery scab has occurred in the last 4 years.

### Bacterial Ring Rot (BRR)

Use tagged seed that had a BRR lab test. Practice complete cleanliness. (See the section *Sanitation*, on page 109.)

### Leaf Roll Virus and Net Necrosis

Aphids may transmit potato leaf roll from an infected potato plant to a clean potato plant during the season. In some varieties, this causes tuber net necrosis. Russet Burbank is quite susceptible to this; Shepody is slightly susceptible. Control aphids by scouting fields and spraying. Use varieties resistant to net necrosis. Plant tagged seed indicating low or absent levels of this disease.

### Pink Eye

Pink eye is characterized by skin-deep, pinkish blotches near the eyes of the apex. The skin of affected tubers dries and cracks easily. Internal reddish-brown to black discolouration, cavities and soft rot are often associated with severe pink eye. The disease appears late in the growing season under conditions of high soil moisture. The causal agent of pink eye is unknown.

If the storage area is properly ventilated, the discoloured tissues dry out, turn light brown and become wrinkled and cracked. If the storage temperature is higher than 7°C and humidity is high, pink eye can spread to other tubers through wounds and lenticels. If there is not enough air circulation, the affected areas may break into water-soaked brown lesions. Increase air flow through the pile to promote drying of pink eye lesions.

There is no chemical control available to reduce the incidence of pink eye in the field. Pink eye is often associated with *Verticillium* and *Rhizoctonia* and good control of these fungal diseases will reduce the incidence of pink eye.

## Insect Management

### *Wireworm, Cutworms and White Grub*

Most cutworms hide in the soil during the day, emerging at night to feed. Chemical controls are most effective if applied to moist soils in the early evening. Refer to Table 6–59, *Potato Insect Control Recommendations*, on page 118. For more information, see the sections *Cutworms* and *Wireworm*, on page 44, and *White Grubs*, on page 45.

### *Colorado Potato Beetle (CPB)*

This insect has developed resistance to most of the insecticides registered for its control.

#### Resistance Management

> **Repeated use of any insecticide is the quickest way to establish resistance in pest populations.**

The less a chemical is used, the longer it will take for a given insect to develop serious resistance to that material. In any insect species, individuals resistant to an insecticide are present in the population, even before the insecticide has been applied in the field. The exact frequency of resistant individuals is not known, but it is thought to be low, between one in a million to one in a billion individuals.

The Colorado potato beetle has demonstrated a tremendous ability to develop resistance to insecticides, which might indicate that the frequency of resistant individuals is at the higher end of this range.

Successive applications of an insecticide will reduce the populations of susceptible CPB but will allow resistant individuals to increase in numbers and to mate, transferring resistance genes to their offspring.

To delay the development of resistance in CPB populations, rotate fields and use plastic-lined ditches, propane flamers and transgenic varieties.

*Crop Rotation:* When fields are rotated, beetles must walk or fly from overwintering sites to newly planted fields. This takes time, and many beetles die before reaching the crop. This results in lower beetle populations than in non-rotated fields.

*Plastic-lined trenches with steep sides:* These ditches trap emerging adults as they walk towards the potato crop from overwintering sites.

*Propane flamers:* Flamers may be used on border rows or whole fields until the crop is 15 cm high.

#### Insect Scouting

Regular field scouting provides accurate information on the pests present, their level of infestation and distribution in the field. This information allows the grower to apply insecticides only when strictly necessary and not on a regular basis.

Timing the sprays results in economic savings and better control of insects. For example, small CPB larvae are much easier to control than adult beetles or large larvae. Growers can reduce the number of insecticide sprays during the season by using these alternative methods.

See Table 6–60, *Colorado Potato Beetle Control Recommendations*, on page 119, for a list of soil-applied and foliar products. Dip tests are recommended before spraying any insecticide because of the high levels of resistance found in CPB populations. Dip tests are very effective in determining which insecticide should provide the best control in your fields.

For more information, consult the OMAF Factsheet, *Colorado Potato Beetle Dip Test: On-Farm Test to Determine Resistance to Pesticides*, Order No. 92-028.

### *Potato Leafhopper, Flea Beetles*

If monitoring indicates a need, see Table 6–59, *Potato Insect Control Recommendations*, on page 118.

### *Aphids*

Green peach aphids are the most common species found on potatoes. If monitoring indicates a need for green peach, potato or buckthorn aphid control, apply one of the insecticides recommended in Table 6–59, *Potato Insect Control Recommendations*, on page 118. Some aphids are showing tolerance to some insecticide materials. Consult your pesticide dealer or a crop consultant for best choice of material.

### *Tarnished Plant Bug*

If monitoring indicates a need, apply one of the foliar sprays recommended in Table 6–59, *Potato Insect Control Recommendations*, on page 118.

### *Late-Season Cutworms*

These pests have caused both tuber and foliage damage. Control of these cutworms can only be obtained when they are active above the soil surface prior to tuber migration and feeding. Thorough penetration of dense foliage is required for optimum control. Consult your crop specialist regarding insect adult flights to aid in spray-timing decisions. Apply one of the pesticides recommended in Table 6–59, *Potato Insect Control Recommendations*, on page 118.

## Table 6–59.
## Potato Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Aphids** | | | | | | |
| **Soil application** | | | | | | |
| imidacloprid | chloronicotinyl | Admire 240 F | 7.5–12 mL per 100 m of row | | 7 | Will also provide control of leafhoppers and fleabeetles. |
| **Foliar applications** | | | | | | |
| methamidophos | organophosphate | Monitor 480 | 1.75–2.25 L | 0.7–0.9 L | 14 | Also kills leafhoppers, tarnished plant bugs and flea beetles. It can be effective against Colorado potato beetle in areas where this insect has not developed resistance to this insecticide yet. 48-hr re-entry period. |
| dimethoate | organophosphate | Cygon 480 E | 0.55–1.1 L | 0.22–0.44 mL | 7 | |
| | | Lagon 480 E | 0.55–1.1 L | 0.22–0.44 mL | 7 | |
| acephate | organophosphate | Orthene 75SP | 0.75–1.1 kg | 0.3–0.44 mL | 21 | Green peach and potato aphids only. Maximum 4 applications per season. |
| pirimicarb | carbamate | Pirimor 50 DF | 450–550 g | 180–220 g | 3 | |
| oxamyl | carbamate | Vydate L | 2.3–3.0 L | 0.92–1.2 L | 7 | Green peach and potato aphids only. 24-hr re-entry period. |
| imidacloprid | chloronicotinyl | Admire 240 F | 200 mL | 80 mL | 7 | Will also control leafhoppers and flea beetles. Maximum 2 applications per year for all uses. **Do not make foliar application after a soil application in the same crop.** |
| **Potato Leafhopper, Flea Beetles, Tarnished Plant Bug** | | | | | | |
| azinphos-methyl | organophosphate | Guthion 240 SC | 2.25–3.5 L | 0.9–1.4 L | 7 | 48-hr re-entry period. Maximum 3 applications per year. |
| | | Sniper 240 E | 2.25–3.5 L | 0.9–1.4 L | 7 | |
| | | Sniper 50 W Clean Pak | 1.1–1.75 kg | 0.44–0.7 kg | 7 | |
| dimethoate | organophosphate | Lagon 480 E | 0.55–1.1 L | 0.22–0.44 L | 7 | Not for flea beetle. |
| | | Cygon 480 E | 0.55–1.1 L | 0.22–0.44 L | 7 | |
| naled | organophosphate | Dibrom | 1.1 L | 0.44 L | 4 | Not for tarnished plant bug. |
| acephate | organophosphate | Orthene 75 SP | 0.75–1.1 kg | 0.3–0.44 kg | 21 | Maximum 4 applications per year. |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.0 L | 0.4 L | 7 | Not for leafhopper. |
| | | Pyrinex 480 EC | 1.0 L | 0.4 L | 7 | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 62.5–125 mL | 25–50 mL | 7 | Use high rate on plant bug. |
| | | Cymbush 250 EC | 140–200 mL | 56–80 mL | 7 | Maximum 3 applications per year. Use high rate on plant bug. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33.2 mL | 7 | 24-hr re-entry period. |
| deltamethrin | pyrethroid | Decis 5 EC | 100–150 mL | 40–60 mL | 3 | Maximum 3 applications per year. |
| permethrin | pyrethroid | Pounce 384 EC | 180–260 mL | 72–104 mL | 1 | |
| oxamyl | carbamate | Vydate L | 2.3–3.0 L | 0.92–1.2 L | 7 | 24-hr re-entry period. |
| carbofuran | carbamate | Furadan 480 F | 0.55–1.1 L | 0.22–0.44 L | 7 | Use high rate on plant bug. 48-hr re-entry period. Maximum 2 applications per year. |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.0–1.5 kg | 0.4–0.6 kg | 1 | Use high rates for plant bug. |
| | | Thiodan 4 EC | 1.5–2.0 L | 0.6–0.8 L | 1 | |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 1 | |
| **Late-Season Cutworms** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4 E | 1.2–2.4 L | 0.48–0.96 L | 7 | |
| | | Pyrinex 480 EC | 1.2–2.4 L | 0.48–0.96 L | 7 | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 175 mL | 70 mL | 7 | |

[1] DHI = Days to Harvest Interval.

## Table 6–60.
## Colorado Potato Beetle Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Soil Treatments** | | | | | | |
| imidacloprid | chloronicotinyl | Admire 240 F | 0.85–1.3 L[2] | 0.34–0.52 mL[2] | | Use 7.5–12 mL per 100 m of row. For best results, spray directly on the seed piece. |
| phorate | organophosphate | Thimet 15 G | 14.5–22.4 kg | 5.8–8.96 kg | 90 | Use the higher rate on heavy silt or clay loam soils. Do not use on muck soils. |
| disulfoton | organophosphate | Di-Syston 15G | 15–22.5 kg | 6–9 kg | 90 | Use the high rate on clay and muck soil. To reduce the possibility of groundwater contamination, alternate soil insecticides each year. For late-season control, apply an appropriate foliar material. |
| **Foliar Sprays** | | | | | | |
| Bacillus thuringiensis | bacterial | Novodor FC | 5.0–8.0 L | 2–3.5 L | 1 | For 1st and early 2nd instar Colorado beetle larvae only; other stages and other insects not controlled. Field scouting is essential for timing the sprays. |
| imidacloprid | chloronicotinyl | Admire 240 F | 200 mL | 80 mL | 7 | Maximum 2 foliar applications per year. DO NOT use foliar Admire on a field where even part (e.g., border rows) of the field has been treated with in-furrow Admire. |
| azinphos-methyl | organophosphate | Guthion 240 SC | 1.75 L | 0.7 L | 7 | Seven days between applications. Maximum 3 applications per year. 48-hr re-entry period. |
| | | Sniper 240 E | 1.75 L | 0.7 L | 7 | |
| | | Sniper 50 W Clean Pak | 0.85 kg | 0.34 kg | 7 | |
| naled | organophosphate | Dibrom | 1.1 L | 0.44 L | 4 | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 62.5–125 mL | 25–50 mL | 7 | |
| | | Cymbush 250 EC | 140 mL | 56 mL | 7 | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83–125 mL | 33.2–50 mL | 7 | Use the higher rate for larger instars and infestations. Maximum 3 applications per year at the 83 mL rate or 2 applications per year at the 125 mL rate. Do not exceed 250 mL per season. 24-hr re-entry period. |
| oxamyl | carbamate | Vydate L | 2.3–3.0 L | 0.92–1.2 L | 7 | 24-hr re-entry period. |
| endosulfan | chlorinated cyclodiene | Thiodan 50 WP | 1.0–1.5 kg | 0.4–0.6 L | 1 | |
| | | Thiodan 4 EC | 1.5–2.0 L | 0.6–0.8 L | 1 | |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 1 | |

[1] DHI = Days to Harvest Interval.

[2] Based on 90-cm (36-in.) row spacing.

## Nematode Management

See the section *Nematodes*, on page 45, for control recommendations.

## Other Problems

### *Sprout Inhibition*

After completion of a rest period, potatoes sprout readily. Potatoes treated with chemical sprout inhibitors can be stored at 10°C or higher without sprouting.

#### Field-Applied

Maleic hydrazide is a plant growth regulator, applied as a single application in the field (for example, Royal MH 60 SG 5.65 kg in 300 L of water) to control sprouting of potatoes in storage. It should be applied in a manner that insures complete and uniform coverage. Timing is important. Recent research has shown that too early an application on some cultivars may result in reduced potato size and phytotoxicity.

Consult manufacturer's recommendations for more detailed information on both rates and timing. Time of application may occur as early as 2–3 weeks past full bloom. Only apply to plants that are still green and free from insects, disease and other damage.

Once in storage, tubers treated with maleic hydrazide will not affect seed potatoes stored in the same storage. Crates formerly used for the storage of maleic hydrazide-treated tubers will not affect seed potatoes.

#### Storage-Applied

CIPC is another chemical that is widely used for sprout inhibition.

Apply it in storage as a dip, spray or aerosol just before sprouting starts. Potato tubers may be treated with this chemical before packaging for market. Do not apply CIPC at harvest time.

Application as a gas to storage bins must be performed by a licensed applicator.

To use CIPC in packing lines, prepare 1 L of Sprout Nip EC in 35 L of water, stir to make an emulsion and use 1 L of this emulsion per tonne of potatoes.

Do not use either of these treatments on potatoes grown for seed. Do not store seed potatoes in the same storage with CIPC-treated tubers, or in crates that were in the storage when CIPC was applied.

### *Vine Killing*

Vine killing is especially important to seed growers as an early kill controls tuber size and reduces the spread of virus diseases by aphids.

Chemical vine killers are not recommended for early potatoes because they limit the yield, size and dry-matter content without reducing skinning.

However, where it is necessary to control size to reduce hollow heart, chemical vine killing may be of value at times for early potato crops.

Use Reglone (Diquat) as follows:

a) Heavy green top growth and weeds: 3.5 L/ha (1.4 L/ac).
b) Medium top growth or crop beginning to mature: 1.7–2.3 L/ha (0.68–0.92 L/ac).
c) Split application: Apply 1.25–2.3 L/ha (0.5–0.92 L/ac) followed by 1.5 L/ha (0.6 L/ac) in 5–6 days.

Apply in at least 550–1,100 L/ha (220–440 L/ac) of clean water. Muddy water may inactivate Reglone. Allow 14–21 days after application until harvest to allow proper vine desiccation and tuber skin set.

**Over-application or conditions that lead to very rapid kill may cause darkening at the stem end of the tuber.**

Aircraft application of Reglone is not recommended. Ensure that no drift occurs from any of these materials to adjacent crops. The residue of these compounds on other crops may result in their seizure.

The product Ignite (glufosinate ammonium) is labelled as a dessicant on table stock and processing potatoes. Do not apply to potatoes grown for seed. Apply 3.0 L in 110–220 L water/ha (1.2 L in 44–88 L water/ac). Use the higher rate of water when the crop canopy is dense. Apply to potato vines 14–21 days prior to harvest.

Within 2–4 days of applying Ignite, symptoms of dessication will appear.

The product "Des-I-Cate" (endothall) is also labelled. Apply to potato vines 10–14 days prior to harvest. Apply 17–22 L/ha (6.8–8.8 L/ac.) Use the high rate for medium to heavy vine growth and during cool (less than 21°C) cloudy weather.

The use of roto-beaters is not recommended except where dead vines or weeds are a hindrance to the digger.

### Storage

Store seed tubers separately from tablestock potatoes, in a disinfected storage area. Do not store seed potatoes in the same storage area with CIPC-treated tubers.

Healing of cuts and bruises is most rapid at a tuber temperature of 15°C–21°C. It is desirable to provide this temperature for 2–3 weeks at the beginning of the storage period. After this, the temperature should be lowered to 5°C if potatoes are intended for tablestock or seed. Potatoes intended for processing should be maintained, preferably, at 10°C and should never be subjected to temperatures below 5°C. It will be necessary to use a sprout inhibitor if potatoes are to be stored at 10°C for an extended period.

The relative humidity in the storage should be as high as possible without causing condensation of moisture on tubers and the storage structure. However, if soft rot is prevalent or if the tubers are wet when first put into storage, the humidity should be kept down until the tubers are dry.

For more information, see the section *Storage*, on page 38.

**Visit the vegetable page on the OMAF Web site at www.gov.on.ca/OMAF/english/crops/hort/vegetable.html**

# RADISHES

## Cultivars

The cultivars listed in Table 6–61, *Suggested Radish Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct their own field trials under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

Cultivars or strains with globe-shaped roots, with entirely red skins and with leaves that are short-to-medium in length are the most popular. Medium-top strains are preferable for early spring crops, and short-top strains preferable during the longer-day period.

Radish, a cool-season crop, is adversely affected by hot, dry weather and remains in prime condition for only a few days. To be mild, tender and attractive, it must be grown rapidly with plenty of moisture. If growth is reduced, the roots become hot, tough and pithy. Under medium-to-short day length, roots are normally well-shaped and tops relatively small. Under long days (15 hr), roots are misshaped and tops are long and usually produce seed stalks.

## Seeding and Spacing

**Rate:** Plant 11–17 kg seed/ha (10–15 lb/ac). For machine harvesting, use 22–34 kg/ha (20–30 lb/ac).

**Spacing:** Plant radish in rows 20–30 cm (8–12 in.) apart, with 40–50 plants/m (3 ft) of row. For machine harvesting, space rows 10–15 cm (4–6 in.) apart.

### *Spring Crop*

The seed may be sown in the spring as soon as the soil is workable. Spring frosts or even snowfalls do not usually injure the crop seriously after the plants have emerged. Under favourable weather conditions, radish seedlings appear above ground 2 or 3 days after sowing. Sowing at intervals in the spring will provide a continuous harvest.

### *Summer and Fall Crop*

Radishes are grown successfully on muck soils throughout the growing season, because such soils are usually well supplied with moisture and provide a cool growing medium. Only large-sized seed of the short-to-medium-foliage cultivars or strains of radishes should be used. On mineral soils, radishes are successfully grown, however heat and drought stresses may be more severe, causing misshapen radishes and excessive top growth in some varieties.

**Table 6–61.**
**Suggested Radish Cultivars**

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Bunching** | | | |
| Red Baron | Description not available, see seed catalogues. | | |
| Red Fortress | | | |
| Red Silk | | | |
| Rudolf | Bejo Seeds | 24 | Short foliage for bunch. |
| **Jumbo** | | | |
| Champion | Seminis | 28 | Strong tops, firm flesh, deep red. |
| Red Crunchy | Description not available, see seed catalogues. | | |
| Scarlet Globe | | | |
| Snow Belle (White) | | | |
| Special | | | |
| **Main Crop** | | | |
| Champion | Seminis | 28 | Strong tops, firm flesh. |
| Cherry Belle | Sakata | | |
| Fuego | Description not available, see seed catalogues. | | |
| Red Cheriette | Description not available, see seed catalogues. | | |
| Reggae | Bejo Seeds | 28 | Excellent colour and pack out. |

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

On mineral soils, apply up to 60 kg N/ha. On muck soils, apply 55 kg N/ha.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

## Disease Management

### Damping-Off

Use seed treated with thiram (dithiocarbamate group) seed protectant. Use 90 g of Thiram 75 WP for every 25 kg of seed. Do not plant seed too deeply and avoid excessive irrigation.

### Rhizoctonia

*Rhizoctonia* on radish can cause severe losses. This fungus attacks the feeder roots and storage root. Loss of yield can occur as a result of interference with nutritional uptake or more likely as a result of deformed and blemished storage roots. Stems and cotyledons can also be damaged. This disease may also take the form of "scurf" on the storage root. This appears as black netting and can be washed off in water.

*Rhizoctonia* prefers cool, wet soils. It usually appears in the spring and fall. Cultural practices that increase soil temperature and decrease soil moisture may provide some relief if the soil inoculum level is not too high. Rotating out of crucifers for 2–3 years should reduce the incidence of this disease.

### Fusarium Wilt (Yellows)

Fusarium yellows or wilt of radish is a soil-borne disease that can seriously affect radishes, especially during warm periods. If the disease attacks the plants when they are small, the leaves will turn yellow and then rapidly turn brown. When the disease attacks more mature radish roots, the plants will appear severely weakened, and the root may become spongy. When cut open, the vascular tissue will be yellowish-brown and sometimes the centre is hollow.

Some varieties of radish have resistance to the disease, which is the only control strategy currently available.

### Downy Mildew

Downy mildew causes damage to radishes especially during cool, damp weather. Symptoms appear as yellow spots on the upper surfaces and greyish-white growth on the undersides of leaves. The disease can also attack the root, causing dark discoloured areas extending down the root from the crown. Infected roots may split or be invaded by secondary rot organisms.

### Black Root

This is another soil-borne disease that is favoured by warm, moist soil conditions. When the disease attacks the radish root, the exterior and interior of the radish will blacken, and often the tops will be stunted. Black root normally begins as a dry rot but is often complicated by the invasion of secondary bacterial rots.

Avoid spreading infected soil between field areas, work crop residues well into the soil and practice rotations of at least 4 years. Some radish varieties may have resistance to the disease.

### Scab

This soil-borne bacterial disease causes scale-like spots that may enlarge to 1–2 cm. Edges of spots are usually raised, and lesions may become infected with secondary rots. Rotations with grains is partially effective. The disease is more severe in lighter, dry soils.

### Other Diseases

Radishes may also be infected by other diseases such as clubroot, alternaria spot, white rust and viruses, however these diseases are generally of low incidence in Ontario except on Asian-type radishes. Consult the section *Specialty Vegetables*, on page 130, for more information.

## Insect Management

### Cabbage Maggot

Using one of the insecticides recommended in Table 6–62, *Radish Insect Control Recommendations*, on page 124, drench the seed at planting time. Later plantings usually require less protection.

### Flea Beetles

To limit the development of resistance, the insecticides listed in Table 6–62, *Radish Insect Control Recommendations*, on page 124, should be used alternately and applied only when monitoring indicates a need.

### Aphids

If monitoring indicates a need, spray with one of the insecticides recommended in Table 6–62, *Radish Insect Control Recommendations*, on page 124.

**Note:** OMAF Publication 701, *IPM for Crucifers in Ontario*, contains a section on radish illustrating many of the common diseases and insect pests.

## Table 6–62.
## Radish Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Cabbage Maggot** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 85 mL /1,000 m of row | | 21 | Drench with seed in 380 L water. |
| | | Pyrinex 480 EC | 85 mL /1,000 m of row | | 21 | Drench with seed in 380 L water. |
| **Flea Beetles** | | | | | | |
| permethrin | pyrethroid | Pounce 384 EC | 175 mL | 70 mL | 2 | |
| carbaryl | carbamate | Sevin XLR plus | 1.25–2.5 L | 0.5–1 L | 7 | |
| **Aphids** | | | | | | |
| diazinon | organophosphate | Diazinon 50 W | 1.1 kg | 0.44 kg | 10 | Control of aphids with these products has been inconsistent in many areas. |
| | | Diazinon 500 EC | 1.1 L | 0.44 kg | 10 | |
| | | DZN 600 EW | 915 mL | 366 mL | 10 | |
| malathion | organophosphate | Malathion 500 E | 1.1–2.75 L | 0.44–1.1 L | 7 | |

[1] DHI = Days to Harvest Interval.

# RHUBARB

## Cultivars

See Table 6–63, *Suggested Rhubarb Cultivars*, right, for recommended cultivars and their descriptions.

## Spacing

Plant in rows 75 cm (30 in.) apart, with plants 75 cm (30 in.) apart in the row (17,220 plants/ha). To produce roots for forcing, spacing in the field may be adjusted to 90 cm (36 in.) between rows and plants (11,950 plants/ha) without any loss of yield or quality.

## Plant Selection

A number of viral and other diseases reduce plant vigour and yield, both in the field and in the forcing shed. Plants with vigorous growth should be marked during June and left in the field until the following spring, then dug up and used as planting stock. Discard the remainder.

## Flower-Stalk Removal

Flower stalks should be cut out while they are still small and before the flowers open. This can conveniently be done at the same time as harvesting a crop for processing, but in crops grown for early fresh market or for forcing, a separate operation will be necessary.

## Site Selection

Rhubarb grows best on loam or heavier cold-bottom but well-drained soil. Variety Sutton grows on lighter soils with irrigation.

## Fertility

### *Nitrogen*

Apply up to 280 kg N/ha for rhubarb to be forced and only up to 200 kg N/ha (split application) for field production.

**Preplanting:** Plow under 45–90 tonnes/ha of manure in the fall. Broadcast and cultivate in 100 kg N/ha, with all of the phosphate and potash required, before planting.

**Annually:** Just before the buds break each spring, apply 100 kg N/ha, with the phosphate and potash required (based on a soil test) as a broadcast application, or preferably as a side-dressing at a 10-cm depth. Immediately after pulling the crop for processing, broadcast 100 kg N/ha. Rhubarb to be forced should receive 180 kg N/ha in July giving a total annual nitrogen requirement of 280 kg/ha.

**Irrigation:** As much as 100 kg N/ha may be applied through the irrigation system after pulling or in July for plants that are to be used for forcing.

**Table 6–63.**
**Suggested Rhubarb Cultivars**

| Cultivar | Variety |
|---|---|
| **Outdoor** | |
| Sutton | Red/green skin colour, green-fleshed variety, grows 100 cm tall, high producer with 20,000–40,000 kg/ha, has some seed stalks. Tart and high yield, often used for processing. Season mid-May through mid-June. |
| Valentine | Red skin and flesh, 75 cm tall, produces 10,000–30,000 kg/ha, few seed stalks. Harvest through June into early July. |
| Macdonald | Red skin, green flesh, grows 75 cm tall, produces 10,000–30,000 kg/ha, some seed stalks. June harvest season. |
| German Wine | Red skin, green flesh, approximately 90 cm tall, 15,000–35,000 kg/ha, some seed stalks. June harvest season. |
| **Forcing** | |
| Victoria | Will produce 1.5–2.5 kg of reddish-pink stalks per plant between early January and mid-May. |
| Sutton | |

**Note:** The use of gibberellic acid (Activol GA) is recommended for rhubarb forcing. Consult label for details.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15).

## Disease Management

### *Crown Rot and Virus Disease*

Remove and destroy diseased plants. Only vigorous, normal plants should be used for propagation.

## Insect Management

### *Potato Stem Borer*

Eggs overwinter in grasses, and by mid-summer the larvae move to larger-stalked plants such as corn, potatoes, tomatoes and rhubarb. Control grassy weeds in and around rhubarb plantings.

### *Rhubarb Curculio*

Destroy dock weeds near the rhubarb planting.

### *Nematode Management*

See the section *Nematodes*, on page 45.

# RUTABAGAS

## Cultivars

The recommended rutabaga cultivars are the Laurentian strains.

## Seeding and Spacing

The optimum soil temperature for germination is from 16°C–29°C. There is a very limited market for early rutabaga crops, seeded in April and May. The main crop, grown for winter storage, should be seeded from mid-June to early July. Rutabagas sown during this time can size up during the cool, fall weather, resulting in improved root quality. Unfortunately, sowings made after mid-June, when large numbers of aphids may move into rutabaga fields, are more vulnerable to virus infection.

| | |
|---|---|
| **Row Spacing:** | 60–90 cm (24–36 in.) |
| **In-Row Spacing:** | 13–15 cm (5–6 in.) |
| **Depth:** | 1.5 cm (0.5 in.) |
| **Rate:** | approx. 500 g of seed/ha (200 g/ac) |

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

Apply up to 35 kg N/ha. Manure may be used in the rotation at the rate of 18–22 t/ha but should be applied at least a year before the rutabaga crop is grown.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

## Secondary and Micronutrients

### *Boron*

Water-core or brown heart may be caused by boron deficiency and first appears in young, enlarging roots as firm, brownish, water-soaked patches. These may increase in size until almost the whole rutabaga root is affected. Severely affected rutabagas may turn punky inside during storage.

Boron can be applied to the soil before sowing. The necessary quantity of boron can be mixed preplant fertilizer applications. Boron-enriched fertilizer should be applied as uniformly as possible.

Foliar applications of Solubor are often as effective as larger amounts applied to the soil. The first foliar application should be made when the roots of the plants are about 1.5–2.5 cm in diameter. The second and third applications may be applied at 10- to 14-day intervals after the first spray.

Do not combine pesticides with boron sprays unless the label specifies compatibility. Excessive applications of boron will often adversely affect the succeeding crop in the rotation (e.g., soybeans, snap beans, white beans and small grains). Consult the section *Boron*, on page 16, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Disease Management

### *Damping-Off*

Use one of the fungicide seed treatments listed in Table 6–64, *Rutabaga Seed Treatments*, below, to minimize damping-off. For more information, refer to the section *Damping-Off of Seedlings*, on page 44.

**Table 6–64.**
**Rutabaga Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Vitavax RS Flowable | carbathiin-thiram-lindane | 22.5 mL per 1 kg of seed | flea beetles[1], damping-off, root rots | Do not store treated seed. |
| Thiram 75 WP | thiram | 90 g per 25 kg seed | seed decay and damping-off | Do not feed treated clippings to livestock. |
| Streptomycin 17 | streptomycin sulfate | 20 g in 10 L of water treats 1 kg seed | black rot | Do not store treated seed.<br>See label for treatment instructions. |

[1] Under high flea beetle pressure, a foliar insecticide may be required.

### Table 6–65. Rutabaga Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Mosaic Virus** | | | | | | |
| mineral oil | N/A | Superior 70 Oil | 10 L in 550–1,100 L water | 4 L in 220–440 L water | 21 | Do not apply mineral oil in direct sunlight. Aphid feeding deterrent only. |
| **Powdery Mildew** | | | | | | |
| propiconazole | triazole | Topas 250 E | 400 mL in 200 L of water | 160 mL in 80 L of water | 21 | A second application may be made 20 days after the first. |
| sulphur | inorganic | Microscopic Sulphur[2] | 6.8 kg in 675–1,125 L of water | 2.75 kg in 270–455 L water | 0 | Maximum 5 applications per year. |

[1] DHI = Days to Harvest Interval.
[2] This product is not compatible with Superior Oil.

### *Black Rot and Blackleg*

See Table 6–64, *Rutabaga Seed Treatments*, on page 126. Do not plant rutabagas, canola, kale, cabbages or other crucifers more than once in 4 or 5 years on the same land. The blackleg pathogen can move with wind and water from adjacent fields that grew a cruciferous crop, including canola, in the previous year. Control cruciferous weeds.

Do not apply manure containing rutabaga refuse or diseased rutabagas on land intended for rutabagas. Do not work in the field when plants are wet. Never store diseased rutabagas. Clean out and disinfect the storage area each spring. See the section *Storage Sanitation*, on page 38.

### *Club Root*

Club root is the most serious disease affecting rutabagas. Use a long crop rotation (at least 5 years) with non-cruciferous crops to avoid infection. Avoid fields known to be infested. See the section *Clubroot*, on page 71.

### *Mosaic Virus*

Losses from turnip mosaic virus are especially heavy in plantings sown after mid-June. Volunteer rutabagas and winter rapeseed are the main overwintering sources of the virus. Aphids transmit the virus to the rutabaga crop.

Applications of mineral oil (Superior 70 Oil) deter the feeding of aphids, which spread TuMv. If monitoring indicates a need, apply as recommended in Table 6–65, *Rutabaga Disease Control Recommendations*, above.

Aphid control does not completely prevent the spread of the virus. For virus control recommendations, consult the OMAF Factsheet, *Turnip Mosaic Virus (TuMV) of Rutabaga*, Order No. 88-091.

### *Powdery Mildew*

The cultivar Laurentian is very susceptible to powdery mildew. The fungus spreads by means of conidia (spores), which are carried long distances by wind. Disease spread occurs rapidly during hot, dry weather. Control must be initiated at the first appearance of symptoms, which are white, circular or star-shaped spots on older leaves and stems. Use the fungicides recommended in Table 6–65, *Rutabaga Disease Control Recommendations*, above. When using sulphur, thorough spray coverage of both upper and lower leaf surfaces is essential for powdery mildew suppression. This may require application at higher spray pressures than normally used.

## Insect Management

### *Cabbage Root Maggot*

Cabbage root maggots overwinter as pupae in the soil in fields where they developed during the previous season. Follow a 3–4-year crop rotation and plant early rutabagas as far as possible away from fields used for rutabagas or cole crops last year. Do not grow early and late rutabagas in the same field or near winter rapeseed, early broccoli, cabbage or cauliflower.

There are three periods of maggot damage related to the emergence of the three generations of flies — early in the season (prior to mid-June), during early July and late in the season (after mid-August). Therefore, control of root maggots can be timed to coincide with the start of the egg-laying activity of each generation of adults. Monitoring programs for cabbage root maggot may help with spray timing. See Table 6–66, *Rutabaga Insect Control Recommendations*, on page 128.

## Table 6–66.
## Rutabaga Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Cabbage Root Maggot** | | | | | | |
| **Treatment at Planting** | | | | | | |
| terbufos | organophosphate | Counter 15 G | 1.5 kg per 1,000 m of row | 0.46 kg per 1,000 ft of row | | Do not apply Counter later than planting. |
| chlorpyrifos | organophosphate | Lorsban 15 G | 210 mL per 1,000 m of row | 64 mL per 1,000 ft of row | | |
| **Treatment After Planting** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 210 mL/ 1,000 m of row (in 125 L of water) | 64 mL per 1,000 ft of row (in 125 L of water) | 28 | Apply on soil, 10 cm on each side of the plant 10 days after seeding. |
| **Subsequent Treatment** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 210 mL per 1,000 m of row | 64 mL per 1,000 ft of row | 28 | Apply on soil, 10 cm on each side of plants 28, 49 and 70 days after seeding. Maximum 4 applications per season. |
| **Flea Beetles** | | | | | | |
| carbaryl | carbamate | Sevin XLR plus | 1.25–2.5 L | 0.5–1.0 L | 7 | |
| permethrin | pyrethroid | Pounce 384 EC | 180 mL | 72 mL | | Apply before 8-leaf stage. |
| cypermethrin | pyrethroid | Cymbush 250 EC | 200 mL | 80 mL | 21 | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2.0 L | 0.8 L | 45 | Use no more than 2 applications per season. |
| | | Thionex 400 EC | 2.0 L | 0.8 L | 45 | |
| **Aphids** | | | | | | |
| dimethoate | organophosphate | Cygon 480 E | 0.7 L | 0.28 L | 7 | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2.0 L | 0.8 L | 45 | Use no more than 2 applications per season. |
| | | Thionex 50 WP | 1.75 kg | 0.7 kg | 45 | |
| **Leaf-Eating Caterpillars** | | | | | | |
| Bacillus thuringiensis | microbial | Dipel 2XDF | 275–550 g | 110–220 g | 0 | Use higher rates for looper control. |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2.0 L | 0.8 L | 45 | Use no more than 2 applications per season. |
| | | Thionex 50 WP | 1.75 | 0.7 kg | 45 | |
| **Cutworms** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.2–2.4 L | 0.5–1.0 L | 30 | May be used at the rate of 2.4 L/ha (1.0 L/ac) as a preplanting treatment. (Apply once at seedling stage (2–5 leaves), when damage first appears.) |
| | | Pyrinex 480 EC | 1.2–2.4 L | 0.5–1.0 L | 30 | |

[1] Days to Harvest Interval.

### *Flea Beetles*

These insects can be controlled only in the adult beetle stage. There is no control for larvae established in roots. A spray should be applied as soon as the beetles appear in the field. Because beetles may migrate into the field over several weeks, a number of applications may be required.

If insecticide drenches are used to control root maggots, flea beetles may also be controlled. If drenches are not applied before seedling emergence and seedlings are attacked when they come up, or if beetles are numerous during the growing season, spray with one of the materials recommended in Table 6–66, *Rutabaga Insect Control Recommendations*, above. To limit the development of resistance, alternate between insecticide groups for each application.

**Before feeding rutabaga tops or trimmings to livestock, check all pesticide labels for restrictions.**

### *Aphids*

If monitoring indicates a threat to the crop, spray with one of the insecticides recommended in Table 6–66, *Rutabaga Insect Control Recommendations*, above. These insecticides are not likely to be effective against aphids if combined with boron sprays.

### *Leaf-Eating Caterpillars*

If cabbageworms, diamondback moth larvae, cabbage loopers, zebra caterpillars, etc., are numerous, spray with one of the pesticides recommended in Table 6–66, *Rutabaga Insect Control Recommendations*, on page 128.

### *Cutworms*

To control dark-sided cutworm, black cutworm and red-backed cutworm, use one of the pesticides recommended in Table 6–66, *Rutabaga Insect Control Recommendations*, on page 128. For more information on cutworm, see the section *Cutworms*, on page 44.

## Nematode Management

See the section *Nematodes*, on page 45, for control recommendations.

***Note:*** The OMAF booklet *IPM for Crucifers in Ontario*, Order No. 701, provides a good summary of IPM for rutabagas in Ontario.

## Post-Harvest

### *Harvesting and Washing*

Avoid bruising. Damaged and bruised rutabagas are likely to rot and do not store well.

Dirty water contains large numbers of rot-causing organisms. To reduce loss from disease after waxing, change the water in the wash tank frequently or add fresh water continuously to keep water as clean as possible. Then rinse rutabagas with clean water and dry them as rapidly as possible before waxing or shipping. Trimming after washing helps reduce rot in waxed rutabagas. Calcium hypochlorite in the rinse water has shown to be effective in reducing losses after waxing.

### *Waxing*

Rutabagas are normally hot-waxed just before being marketed. Waxing improves their appearance, keeps them clean, protects freshly trimmed surfaces from disease organisms and prevents undue moisture loss and shrinkage during the marketing period. Waxing is not recommended for rutabagas being held in storage. Immerse clean, dry rutabagas for one second in a "rutabaga/turnip" wax at 126°C and then pack as desired for market. Temperatures must be kept low after waxing as rutabagas can spoil within a few days at room temperature. Rutabaga wax is available at International Group Incorporated (IGI), 50 Salome Dr., Agincourt, Ontario (Tel. (416) 293-4151). Ask for "turnip wax" — product code 2291.

### *Storage*

Never put diseased rutabagas in storage. Disease-free rutabagas will keep up to 6 months if stored at 0°C and a relative humidity of 90%–95%. Adequate ventilation and air movement throughout the storage area are necessary.

Clean the storage area thoroughly in the spring. To disinfect the area, spray all surfaces with a mixture of 1 kg of copper sulfate (bluestone) and 2 kg of hydrated lime, dissolved in 50 L of water. Add the lime last. Since this mixture is corrosive to metals, cover metal fixtures such as fans, electrical control equipment, etc., during the spraying operation. An alternative disinfectant spray is a 200 ppm solution of calcium hypochlorite. In addition, there are also other commercial disinfectants such as DCD available (see Table 4–12, *Proven Disinfectants*, on page 40).

**Visit the vegetable page on the OMAF Web site at**
**www.gov.on.ca/OMAF/english/crops/hort/vegetable.html**

# SPECIALTY VEGETABLES

A variety of vegetables that are traditionally associated with regions outside of North America are grown in Ontario. Many of these vegetables are of Asian and Middle Eastern origin. These crops belong to a range of plant families including legumes, cole crops, cucurbits and others. Pest management strategies developed for other crops in Ontario may be helpful in these crops, since many of the pests and diseases are similar. There are also new and unique problems associated with these crops and the selection of pest control products available for such crops is limited.

## Nomenclature

Many of the crops of Asian origin have different names depending upon the language used (Mandarin Chinese, Cantonese Chinese, Vietnamese, Korean or Japanese, for example). Table 6–67, *Specialty Vegetables*, on page 131, summarizes some of the Asian specialty vegetable crops grown in Ontario.

For more information, consult the OMAF Factsheets *Asian Vegetables Grown in Ontario*, Order No. 98-033, and *Chinese Cabbage Production in Southern Ontario*, Order No. 86-090.

## Fertility

Because of the wide range of specialty crops, a single fertility recommendation cannot be made, however, a fertility program based on a soil test can form the basis for good crop health. A proper balance of nitrogen, phosphorus and potassium as well as an understanding of the micronutrient requirements (zinc, boron, magnesium, manganese, copper, molybdenum, calcium, etc.) of each crop may be helpful. Experience from traditional Ontario cole crops and cucurbits will also be useful.

## Disease Management

Growers should be aware that many of the diseases affecting these crops may be seed-borne. Ensure, where possible, that the seed is certified as disease-free or within acceptable guidelines. Hot water seed treatments may also be helpful. (See the section *Hot-Water Treatment*, on page 152.)

Cultural practices can help growers reduce disease problems. To reduce disease problems, it is important to use treated seed, deep-plow crop residues into the soil, eliminate cull piles, rotate crops annually, remove weed hosts, reduce overhead irrigation and use healthy transplants grown in clean plug trays and sanitized greenhouses. For chemical control options, see Table 6–68, *Specialty Vegetables Disease and Insect Control Recommendations*, on page 132.

## Common Diseases of Specialty Vegetables

**Asian radish (lo bok, daikon, moo):** turnip mosaic virus, downy mildew, alternaria leaf blight

**Nappa cabbage (siew choy, da bai cai, baechu):** turnip mosaic virus, downy mildew, soft rot, alternaria leaf spot, clubroot, pseudocercosporella leaf spot

**Bok choy, gai choy, yow choy, pak choy, gai lan, etc.:** turnip mosaic virus, downy mildew, soft rot, clubroot, pseudocercosporella leaf spot, alternaria leaf blight

**Cucurbits (fuzzy squash, bitter melon, winter melon):** powdery mildew, mosaic viruses, bacterial wilt, angular leaf spot, scab, anthracnose

## Insect Management

### *Aphids, Cutworms, Cabbage Looper, Diamondback Moth, Imported Cabbageworm, Tarnished Plant Bug, Cabbage Maggot*

See Table 6–68, *Specialty Vegetables Disease and Insect Control Recommendations*, on page 132, for control recommendations.

For more information, refer to:

- OMAF Publication 701, *IPM for Crucifers in Ontario*
- OMAF Factsheet, *Tarnished Plant Bug Danage on Vegetable Crops in Ontario*, Order No. 98-025.

## Table 6–67. Specialty Vegetables

| English | Chinese | Korean | Japanese | Vietnamese | Latin |
|---|---|---|---|---|---|
| Edible amaranth (callaloo, tampala) | hinn choy (C), xian cai (M) | chambirum | hi yu na | rau den do | *Amaranth mangostanus*<br>*A. gangeticus* |
| Asian water celery or Water dropwort | shui qin (M) | minari | seri | cang nuoc,<br>rau can nuoc | *Oenanthe stolonifera* |
| Asparagus bean or Snake bean | dau guak (C), cai dow (M) | gin kong | sasage | dua-dua | *Vigna unguiculato*<br>var. *sesquipedalis* |
| Bitter melon | ku gua (M), fu gua (C) | ssunoi | ni ga uri | muop dang,<br>khoqua | *Momordica charantia* |
| Bitter melon leaves | fu gua yip | | | la khoquo | *Momordica charantia* |
| Burdock root | ngao pong (C) | uang | gobo | | *Arctium lappa* |
| Chinese broccoli or Chinese kale | gai lan (C), jie lan (M) | | kailaan | cai ro | *Brassica alboglabra* |
| Nappa cabbage or Chinese cabbage | siew choy (C), won bok (C), da bai cai (M), huan ya bai (M) | baechu | hakusai | cai bac thao,<br>cai dai | *Brassica rapa*<br>var. *pekinensis* group |
| Chinese chives | gow choy (C), jiu cai (M) | buchu | nira | he | *Allium tuberosum* |
| Chinese cucumber | wong gua (C), huang gua (M) | oi | | dua leo | *Cucumis sativus* var. *sativus* |
| Big leaf mustard | dai gai choy (C), da jie cai (M) | gat | karashina | cai zanh | *Brassica juncea* var. *involutus;*<br>var. *foliosa* |
| Chinese okra or Sponge gourd | guang dong si gua, si gua | | shokuyou hechima,<br>hechima | muop khia,<br>muop huong | *Luffa acutangula,*<br>*Luffa aegypitaca* |
| Chinese squash/pumpkin | nam gua (C), nan gua (M) | ho bak | kabocha | bi ro | *Cucurbita moschata* |
| Japanese pumpkin | yin du nan gua | | seiyou-kabocha | bi | *Cucurbita maxima* |
| Chrysanthemum greens | tong hao cai (M),<br>tong ho choy (C) | ssukgat | shungiku | tan o, cai cui | *Chrysanthemum coronarium* |
| Flowering edible rape | yow choy (C), you cai (M) | yuchaeip | aburana | cai ngot | *Brassica rapa* var. *oleifera* |
| Fuzzy squash | mao gua, jie gua (M),<br>tsit gua (C) | ho bak | tohgan | bi chanh | *Benincasa hispida*<br>var. *chieh-qua* |
| Edible mallow (melokhia) | | | | rau day | *Corchorus olitorius* |
| Red/green mustards | gai choy (C), jie cai (M) | gat | karashina | cai xanh | *Brassica juncea* var. *rugosa;*<br>var. *crispifolia* |
| Malabar spinach | lo kwai (C), san choy (C),<br>zi luo kui (M), lu luo (M) | | tsuru-murasaki | mong to'i | *Basella alba,*<br>*Basella rubra* |
| Flowering Chinese leaf cabbage | choy sum (C), cai xin (M) | | saishin | cai ngot non | *Brassica rapa*<br>var. *parachinensis* |
| Flat flowering Chinese leaf cabbage | nai yow choy (C) | | | | *Brassica rapa* var. *narinosa* |
| Rosette Chinese leaf cabbage | tak choy (C), wu ta cai (M) | | tatsoi | cai tua xai | *Brassica rapa* var. *rosularis* |
| Purple mint, beefsteak plant | zi su (C) | dulketip | shiso | tia to | *Perilla frutescens,*<br>*Perilla crispa* |
| Asian radish | lo bok (C), luo bu (M) | moo | daikon | cu-cai | *Raphanus sativum*<br>*Longipinnatus* group |
| Potherb mustard | shui cai (C) | | kyona, mizuna | | *Brassica juncea* var. *japonica* |
| Salad rocket (arugula) | | | | | *Eruca vesicaria* |
| Snow peas | ho lan dow | wando | saya endo | | *Pisum sativum* var. *macrocarpon* |
| Snow pea shoots | dow miu (C), dou miao (M) | wandusun | tohbyo | | *Pisum sativum* var. *macrocarpon* |
| Thick petiole white Chinese leaf cabbage | bai cai (M), bok choy (C) | bok choy | shakushina | cai thuong hai | *Brassica rapa* var. *chinensis* |
| Thin petiole white Chinese leaf cabbage | pak choy (C), xiao bai cai (M) | pak choy | shakushina,<br>chingensai (green stem) | cai trang laon | *Brassica campestris rapa*<br>var. *chinensis* |
| Water spinach | tung choy (C), kongxin cai (M) | kongshim-chae | kankon, asagaona, ensai | rau muong | *Ipomoea aquatica* |
| Winter melon | tung kwa (C), don gua (M) | | tohgan | bao | *Benincasa hispida* |

## Table 6–68.
## Specialty Vegetables Disease and Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Downey Mildew** | | | | | | |
| fosetyl-al | phosphonate | Aliette 80 WDG | 2.25–3.12 kg | 0.9–1.25 kg | 7 | Bok choy only. Maximum 5 applications per year. 12-hr re-entry period. |
| **Aphids** | | | | | | |
| dimethoate | organophosphate | Cygon 480 E | 0.6–1.0 L | 0.24–0.4 L | 7 | Chinese broccoli, Chinese cabbage, pak choy. Maximum 3 applications per year. |
| | | Lagon 480 E | 0.6–1.0 L | 0.24–0.4 L | 7 | |
| naled | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | Mustard greens. Maximum 3 applications per year. |
| **Cutworms** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 2.4 L | 0.96 L | 32 | Chinese cabbage: Preplant. |
| | | | 1.2–2.4 L | 0.48–0.96 L | 32 | Chinese cabbage: Seedlings. |
| | | Pyrinex 480 EC | 2.4 L | 0.96 L | 32 | Chinese cabbage: Preplant. |
| | | | 1.2–2.4 L | 0.48–0.96 L | 32 | Chinese cabbage: Seedlings. |
| **Cabbage Looper, Diamondback Moth, Imported Cabbageworm** | | | | | | |
| Bacillus thuringiensis | microbial | Dipel 2XDF | 275–550 g | 110–220 g | 0 | Mustard greens. |
| | | | 55–550 g[2] | 22–220 g[2] | 0 | Chinese cabbage, Chinese broccoli, bok choy, Asian radish.[2] |
| | | Thuricide HPC | 2.0–4.25 L | 0.8–1.7 L | 0 | Mustard greens. |
| carbaryl | carbamate | Sevin XLR plus | 2.5–5.25 L | 1–2.1 L | 21 | Chinese cabbage, mustard greens. |
| naled | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | Mustard greens (looper only). |
| permethrin | pyrethroid | Pounce 384 EC | 90–180 mL | 36–72 mL | 3 | Pak choy, Chinese cabbage. Maximum 4 applications per year. |
| | | | | | 7 | Chinese broccoli. Maximum 4 applications per year. |
| azinphos-methyl | organophosphate | Guthion 50 WP Solupak | 1.12–1.75 kg | 0.45–0.7 kg | 21 | Chinese cabbage. Maximum 3 applications per year. |
| **Flea Beetles** | | | | | | |
| carbaryl | carbamate | Sevin XLR plus | 1.25–2.5 L | 0.5–1 L | 21 | Chinese cabbage, mustard greens. |
| **Tarnished Plant Bug** | | | | | | |
| carbaryl | carbamate | Sevin XLR plus | 2.5–5.25 L | 1–2.1 L | 21 | Chinese cabbage, mustard greens. |
| **Cabbage Maggot** | | | | | | |
| azinphos-methyl | organophosphate | Guthion 50 WP Solupak | 1 kg in 1,000 L water | 0.4 kg in 400 L water | 21 | Chinese cabbage. Apply 115–170 mL per plant at or immediately after transplanting. |
| | | Guthion 240 SC | 2 L in 1,000 L water | 0.8 L in 400 L water | 21 | |
| chlorpyrifos | organophosphate | Lorsban 4E | 210 mL/ 1,000 m of row | 64 mL/ 1,000 ft of row | 15 | Chinese cabbage, pak choy only. Apply 7–10 days after seeding or 3 days after transplanting. Repeat 21 days after transplant drench or 28 days after seeding. |
| | | | 150 mL/ 1,000 m of row | 45 mL/ 1,000 ft of row | 21 | Chinese broccoli (gai lan, kailaan). Apply 5–7 days after seeding. |
| | | | 210 mL/ 1,000 m of row | 64 mL/ 1,000 ft of row | 32 | Asian-type radish (lo bok, daikon, moo). Apply 7, 20 and 35 days after seeding. |
| | | Pyrinex 480 EC | 150 mL/ 1,000 m of row | 45 mL/ 1,000 ft of row | 21 | Chinese broccoli (gai lan, kailaan). Apply 5–7 days after seeding. |
| | | | 210 mL/ 1,000 m of row | 64 mL/ 1,000 ft of row | 32 | Asian-type radish (lo bok, daikon, moo). Apply 7, 20 and 35 days after seeding. |

---

[1] DHI = Days to Harvest Interval.

[2] Dipel 2XDF rates vary depending on the pest. Diamondback moth = 275 mL/ha, cabbage looper = 275–550 mL/ha, imported cabbageworm = 55–140 mL/ha.

# SPINACH & SWISS CHARD

## Cultivars

Spinach varieties listed in Table 6–69, *Suggested Spinach Cultivars*, right, are suggestions for Ontario from seed companies, growers, researchers and extension personnel. Other varieties may be suitable for your area or market. Growers are encouraged to conduct field trials themselves to evaluate varieties under local growing conditions. Check with a range of seed company representatives for additional recommendations and variety descriptions.

Consult your local seed company representatives for Swiss chard cultivars recommended in your growing area.

## Bolting

Spinach quickly bolts (produces flowerstalks) under long-day and warm-weather conditions, so the crop is produced mostly in the spring or fall. Cool weather reduces the long-day effect. Spinach grown in cool summers may not bolt quickly. Bolting may also be hereditary. Strains of spinach deteriorate in quality if the seed producer allows the quick-bolting types to increase.

## Seeding and Spacing

Sow outside as soon as soil can be worked in early spring until early May, or from July 31 to August 31 for a fall crop. Do not sow seed in mid-summer, because bolting may occur. For over-wintered spinach, sow from September 1–10.

Fresh seed will germinate readily at soil temperatures as low as 3°C–4°C, and good results are obtained at 10°C–16°C. At higher temperatures, there is a more rapid emergence but decreased percentage germination.

| | |
|---|---|
| **Row Spacing:** | Spinach: 30 cm (12 in.)<br>Swiss chard: 30 cm (12 in.) |
| **In-Row Spacing:** | Spinach: 5–10 cm (2–4 in.)<br>Swiss chard: 10–12 cm (4–5 in.) |
| **Rate:** | Approximately 12 kg of seed will plant 1 ha (4.8 kg/ac). |

## Soil

Sandy or sandy-loam soils are preferred for the early and over-wintered crops. The highest yields are obtained on muck soils. Muck soils have a high water-holding capacity and are well-aerated. Since spinach is somewhat sensitive to soil acidity, a test should be made before planting the crop. The ideal range for spinach is a pH of 6.5–7.5.

**Table 6–69.**
**Suggested Spinach Cultivars**

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Savoyed** | | | |
| Long Bloomsdale | | | Spring, limited seed supply. |
| Melody (semi-savoyed) | Seminis | | Summer, fall and overwintering. |
| **Smooth** | | | |
| Olympia | Chriseeds | | No description available. |
| Springfield | Bejo Seeds | 40 | Resistant to downy mildew (strains 1, 2, 3, 4). Vigorous, slow bolting. |
| Springer | Bejo Seeds | 39 | Resistant to downy mildew (strains 1, 2, 3, 4). Very slow bolting. |
| Spinter | | | |
| Unipak 151 | Seminis | | Medium leaf type. |
| Unipak 12 | Seminis | | |

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19).

**Mineral soils:** Apply up to 110 kg N/ha. For early sown crops, apply all of the nitrogen preplant. For mid- and late-season crops, apply 55 kg at planting followed by an additional 55 kg if rainfall has been excessive.

**Muck soils:** Apply 75 kg N/ha. If rainfall has been excessive, an additional 55 kg may be applied as a side-dress application.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 15.

### *Boron*

Boron deficiencies on spinach and swiss chard are not common but may occur during periods of hot, dry

## Table 6–70.
## Spinach and Swiss Chard Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Leaf Miners** | | | | | | |
| parathion | organophosphate | Parathion 960 EC | 225–375 mL | 90–150 mL | 7 | Spinach only. 7-day re-entry period. |
| malathion | organophosphate | Malathion 25 W | 5.5–7.0 kg | 2.2–2.8 kg | 7 | Spinach only. |
| diazinon | organophosphate | Diazinon 50 WP | 1 kg | 0.4 kg | 10 | Spinach only. |
| | | Diazinon 500 EC | 1.1 L | 0.44 L | 10 | |
| | | DZN 600 EW | 915 mL | 366 mL | 10 | |
| **Aphids** | | | | | | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2 L | 0.8 L | 14 | Spinach only. Maximum 1 application per year. |
| | | Endosulfan 50 W | 1.75 kg | 0.7 kg | 14 | |
| | | Thionex 50 WP | 1.75 kg | 0.7 kg | 14 | |
| diazinon | organophosphate | Diazinon 50 WP | 1.0 kg | 0.4 kg | 10 | Spinach only. Control of aphids with diazinon has been inconsistent in many areas. |
| | | Diazinon 500 EC | 1.1 L | 0.44 L | 10 | |
| | | DZN 600 EW | 915 mL | 366 mL | 10 | Spinach. |
| | | | | | 14 | Swiss chard. Control of aphids with diazinon has been inconsistent in many areas. |
| parathion | organophosphate | Parathion 960 EC | 225–375 mL | 90–150 mL | 7 | Spinach only. 7-day re-entry period. |
| dimethoate | organophosphate | Cygon 480 E | 700 mL | 280 mL | 7 | Maximum 2 applications per season. |
| | | Lagon 480 E | 700 mL | 280 mL | 7 | |
| naled | organophosphate | Dibrom | 1.1–1.65 L | 0.44–0.66 L | 4 | Spinach only. Control of aphids with naled has been inconsistent in many areas. |
| pirimicarb | carbamate | Pirimor 50 DF | 500 g | 200 g | 7 | Spinach only. 24-hr re-entry period. Maximum 3 applications per year. |
| **Cabbage Looper, Beet Webworm** | | | | | | |
| Bacillus thuringiensis | microbial | Thuricide HPC | 2.0–4.25 L | 0.8–1.7 L | 0 | Spinach only. Looper only. |
| | | Dipel 2XDF | 275–550 g | 110–220 g | 0 | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 2 L | 0.8 L | 14 | Spinach only. Looper only. Maximum 1 application per year. |
| | | Endosulfan 50 W | 1.75 kg | 0.7 kg | 14 | |
| | | Thionex 50 WP | 1.75 kg | 0.7 kg | 14 | |
| parathion | organophosphate | Parathion 960 EC | 225–375 mL | 90–150 mL | 7 | Spinach only. Webworm & looper. 7-day re-entry period. |
| naled | organophosphate | Dibrom EC | 1.1–1.65 L | 0.44–0.66 L | 4 | Spinach only. Looper only. |

[1] DHI = Days to Harvest Interval.

weather. Leaves become twisted with light spots developing on the petioles. Internal breakdown may occur in the roots or may appear on the root surface as external cankers. See the section *Boron*, on page 16, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### Magnesium

A magnesium deficiency may occur on spinach. The usual symptoms are yellowing of older leaves while the veins remain dark green. Consult the section *Magnesium*, on page 13, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### Table 6–71.
### Spinach Seed Treatments

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Apron XL-LS | metalaxyl-m | 20–40 mL per 100 kg seed | damping-off | Export use only. Not for greenhouse-grown spinach. |
| Thiram 75 WP | thiram | 90 g per 25 kg seed | seed decay and damping-off | |

## Disease Management

### *Damping-Off*

Use one of the fungicide seed treatments listed in Table 6–71, *Spinach Seed Treatments*, above, to minimize damping-off. For more information, see the section *Damping-Off of Seedlings*, on page 44.

### *Downy Mildew and Mosaic Virus*

Grow a resistant cultivar. Do not grow a fall crop in, or adjacent to, a field where an infected spring crop was grown.

### *Fusarium Wilt and Root Rot*

In soils where this disease is a problem, do not seed spinach between May 31 and August 15. Some tolerance may exist in some varieties. Check with your seed company representatives for further information.

## Insect Management

### *Aphids, Leaf Miners, Cabbage Looper and Beet Webworm*

See the sections *Aphids*, on page 65, *Leaf Miners* and *Cabbage Looper*, on page 66, and *Webworm*, on page 56. If monitoring indicates a need, use one of the pesticides recommended in Table 6–70, *Spinach and Swiss Chard Insect Control Recommendations*, on page 134. Prevent the development of resistance by rotating between pesticide groups.

## Nematode Control

To avoid damage from sugarbeet cyst nematode, do not plant spinach following rhubarb, beets or spinach. (See the section *Nematodes*, on page 45.)

**Looking for information on post-harvest crop management?**
**See the section *Storage*, on page 38.**

# SUGARBEETS

## Cultivars

Follow processor's requirements.

## Field Seeding and Spacing

Plant enough seed to give an emerged stand of 150–180 sugarbeets per 30 m (100 ft) of row. See Table 6–72, *Sugarbeet Row Spacing*, right. These spacings will consistently produce more recoverable sugar per hectare than lower stands.

Depth of planting will vary with soil types and moisture conditions. A 2.5 cm (1 in.) planting depth is generally satisfactory. For highest yield potential, seed sugarbeets early as weather, soil moisture and temperature conditions permit.

Proper planter set-up and maintenance are extremely important for successful establishment of the sugarbeet stand. Good seedbed preparation is also important to achieve early seeding dates, rapid seedling emergence and a uniformly spaced stand.

## Fertility

### *pH*

Sugarbeets will perform best at a pH of 6.5 to 7.2. Manganese deficiency may become a problem above pH 7.2.

**Note for fields with a history of Pursuit application:** Pursuit degrades very slowly at pH less than 6.0–6.5. It also takes time after the application of lime for the pH to fully adjust. Allow for sufficient time for herbicide breakdown after the pH adjustment.

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

After field corn, use 120–150 kg N/ha. Reduce nitrogen application to 100–130 kg when following other crops. Excess nitrogen will not increase sugarbeet yield. It often has an adverse effect on sugar content and clear juice purity.

### *Phosphate and Potash*

Soil tests should be used to determine phosphate and potash requirements. Excess application of potassium will lead to luxury consumption of potassium by the sugarbeet plant. This has a negative effect on clear juice purity. See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.

**Table 6–72.**
**Sugarbeet Row Spacing**
Based on 50–55 cm (20–22 in.) row width

| | Seed spacing needed to achieve: | | | |
|---|---|---|---|---|
| | 180 sugarbeets per 30 m (100 ft) of row | | 150 sugarbeets per 30 m (100 ft) of row | |
| Expected % Emergence | cm | in. | cm | in. |
| 40 | 6.8 | 2.7 | 8.1 | 3.2 |
| 50 | 8.4 | 3.3 | 10.2 | 4.0 |
| 60 | 10.2 | 4.0 | 12.2 | 4.8 |
| 70 | 11.9 | 4.7 | 14.2 | 5.6 |
| 80 | 13.5 | 5.3 | 16.3 | 6.4 |

***Note:*** Normal emergence is approximately 60% in our growing areas. Aim for a minimum emergence of 180 sugarbeets/30 m (100 ft) in 71–76 cm (28–30 in.) rows and 150 sugarbeets/30 m (100 ft) in 51–56 cm (20–22 in.) rows.

### *Starter Fertilizer*

Fields with high soil test levels of phosphorus and potassium do not generally require starter fertilizer. When banding, place starter fertilizer at least 5 cm to the side and 5 cm below the seed to avoid seedling injury.

### *Manganese*

Manganese deficiencies most often occur on heavier textured soil with high pH and higher soil organic matter levels. Deficient plants show marked yellowing between the leaf veins; the veins themselves remain green. If soybeans regularly exhibit manganese deficiencies in the field, then manganese deficiency may also occur in sugarbeets. To correct a deficiency, spray with manganese sulfate, consult the section *Manganese*, on page 17, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### *Boron and Zinc*

Research in Michigan has not indicated a need for boron and zinc.

*Caution:* Crops vary widely in their requirements for and tolerance for boron. The line between deficient and toxic is narrow. There is a concern with boron (especially band applied) and seed corn in rotation.

**Table 6–73.**
**Sugarbeet Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| Apron XL LS | metalaxyl-m | 20–40 mL per 100 kg seed | damping-off and root rots | For use in commercial seed treatment plants only. |
| Thiram 75 WP | thiram | 90 g per 25 kg seed | seed decay and damping-off | Do not feed treated clippings to livestock. |

## Disease Management

### *Damping-Off and Seedling Diseases*

Varieties recommended by the processor have considerable tolerance to seedling diseases and damping-off. See Table 6–73, *Sugarbeet Seed Treatments*, above, and the section *General Insects and Diseases of Vegetable Crops*, on page 44.

### *Cercospora Leaf Spot*

This fungus attacks the leaf, interfering with root growth and sugar storage. It is imperative to minimize leaf damage. Subsequent regrowth of the foliage is at the expense of the beet itself, resulting in lower yields and lower sugar content.

Sugarbeet varieties have varying levels of leaf spot tolerance. Follow a well-timed fungicide program to control this economically significant disease. The timing of the first fungicide spray is critical.

Scout your fields to identify the onset of cercospora leaf spot. The initial spray should then be applied when the weather forecast is favourable for disease development:

- air temperatures above 24°C (75°F)
- extended periods of leaf wetness due to rain showers, heavy dews or lingering fog

In an average season, control measures are needed by mid-July. A timing program for fungicide application has been developed and can be accessed through the Ontario Weather Network (OWN). OWN monitors weather conditions influencing disease development and provides growers with the information needed to make spray timing decisions. Call OWN at (519) 674-1532 for more information.

Apply control products as indicated in Table 6–74, *Disease and Insect Control Recommendations for Sugarbeets*, on page 138. The initial spray should be a contact-type fungicide. A systemic fungicide (Senator) should generally be applied as the second spray. To avoid the development of fungicide-resistant cercospora leaf spot, do not apply Senator 70 WP more than once per season.

Past mid- to late September, no further fungicide sprays are warranted, especially if night and day temperatures remain below 15°C (59°F).

### *Rhizoctonia Crown Rot*

Crown rot attacks the base of the leaf petioles and crown of the sugarbeet late in the season, causing the plants to die along the row or in circular patterns in the field. The best way of controlling this disease is to avoid throwing soil onto sugarbeet crowns during cultivation. Crop rotation with corn or small grains is also helpful. Avoid dumping sugarbeet tare dirt onto fields going into sugarbeets the following year.

### *Powdery Mildew*

Powdery mildew is generally not a serious problem in the Ontario growing area. The pathogen affecting sugarbeets does not overwinter in Ontario. Occasionally it is blown in from western sugarbeet growing areas causing sporadic infestations.

## Insect Management

### *Leaf Miners*

Leaf miner flies emerge early in the season and lay eggs on the underside of sugarbeet leaves. The maggots tunnel or "mine" inside the leaf. Lamb's-quarters is an alternate host to this pest. Good weed control can reduce infestations.

If eggs are found on more than 50% of the young plant, apply one of the products listed in Table 6–74, *Disease and Insect Control Recommendations for Sugarbeets*, on page 138, when the first mines are seen.

### *Root Aphid*

Root aphids are a localized but serious pest in some years.

### *Tarnished Plant Bug, Leafhoppers, Flea Beetles*

These pests are present in sugarbeet fields in Ontario, but economic injury has not been observed.

### Table 6–74.
### Disease and Insect Control Recommendations for Sugarbeets

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Cercospora Leafspot** | | | | | | |
| thiophanate-methyl | benzimidazole | Senator 70WP | 0.42–0.56 kg | 0.17–0.22 kg | 21 | Systemic. Always rotate with contact type compound. Follow an IPM and resistance management strategy. Maximum 1 application per season. |
| mancozeb | dithiocarbamate | Manzate 200DF | 2.25 kg | 0.9 kg | 21 | Apply every 7–10 days. |
| | | Dithane M-45 | 2.25 kg | 0.9 kg | 21 | |
| | | Penncozeb 80 WP | 2.25 kg | 0.9 kg | 21 | |
| cupric hydroxide | inorganic | Kocide 101 | 2.25–4.5 kg | 0.9–1.8 kg | 1 | Apply every 10–14 days. Add suitable non-herbicidal agricultural oil at 5.5 L/ha. |
| copper hydroxide | inorganic | Parasol | 2.25–4.5 kg | 0.9–1.8 kg | 1 | Apply at 10–14-day intervals once disease is detected. Add suitable non-herbicidal agricultural oil at 5.5 L/ha. |
| **Wireworm, Sugarbeet Maggot** | | | | | | |
| terbufos | organophosphate | Counter 15 G | 45 g/100 m of row | 13.7 g/100 ft of row | | Apply at planting. Do not place in direct contact with seed. Rates based on minimum 50 cm (20 in.) spacing. |
| **Cutworms** | | | | | | |
| chlorpyrifos | organophosphate | Lorsban 4E | 1.2–2.4 L | 0.5–1.0 L | 90 | 24-hr re-entry period. |
| **Flea Beetles, Leaf Miners, Leafhoppers, Spider Mite** | | | | | | |
| malathion | organophosphate | Malathion 500 | 1.1 L | 0.44 L | | Flea beetles. Apply at the 3–5 leaf stage when insects or damage first appears. |
| naled | organophosphate | DiBrom | 2.2 L | 0.9 L | 5 | Red spider mites, leafhoppers. |
| **Sugarbeet Cyst Nematode** | | | | | | |
| dichloropropene/ chloropicrin | | Telone C-17 | 160 L | 65 L | 120 | Mineral soils. Applied before planting. 72-hr re-entry period. |

[1] DHI = Days to Harvest Interval.

***Note:*** As the Ontario sugarbeet crop is processed entirely in the U.S., all products used must have both Canadian and U.S. registrations on sugarbeets. Your processor may have specific restrictions and recommendations. **Check with your processing company representative before spraying.**

## *Cutworms*

Cutworms are only a minor problem in Ontario. If monitoring indicates a problem, see Table 6–74, *Disease and Insect Control Recommendations for Sugarbeets*, above. Cutworm controls are most effective if applied to moist soils in late afternoon or early evening. For more information, see the section *General Insects and Diseases of Vegetable Crops*, on page 44.

## Sugarbeet Cyst Nematode

Rotation to non-host crops for 4–5 years will significantly reduce populations of this nematode. Avoid rotation with other host crops including table beets, cruciferous crops and rhubarb. (See the section *Nematodes*, on page 45.)

## Quality and Storage

Sugarbeets should be handled as gently as possible to minimize breakage and bruising. Damaged sugarbeets will not store well in piles. Flails should be adjusted to remove all green leaf material from crowns. Flail only the amount of sugarbeets to be harvested each day, as topped beets will freeze in the field much more quickly than beets with tops.

Frosted or frozen sugarbeets deteriorate rapidly in the pile. When sugarbeet crowns are frosted or frozen in the field, delay harvest until the tissue has had a chance to thaw and stabilize.

# SWEET CORN

## Cultivars

The varieties listed in Table 6–75, *Sweet Corn Cultivars With Disease-Resistance Traits*, on page 140, highlight some of the cultivars with disease-resistance traits available on the market. It is not a complete list. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed companies for additional recommendations and variety descriptions.

For processing variety selection, refer to the company field representatives.

## Seeding and Spacing

**Row Spacing:** 75 cm (30–36 in.)
**In-Row Spacing:** 20–25cm (8–10 in.)
**Rate:** 11–17 kg seed/ha (10–15 lb/ac)
**Depth:** 4–7.5 cm (1.5–3 in.)

Smaller, earlier maturing varieties can be planted at higher densities while the larger, later varieties require more room to grow and develop. If only one row width is practical, it is more critical to use wider spacing to accommodate the larger, main-season plants.

## Soil Temperature

Minimum soil temperature for germination depends on the cultivar and its gene type. In general, Normal (su) cultivars require 13°C, Sugar Enhanced (se) cultivars require 16°C, and Supersweet (sh2) cultivars require 18°C.

## Fertility

### *Nitrogen*

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 18, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 19.)

On all soils, 90 kg N/ha is recommended.

### *Phosphate and Potash*

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.)

### *Application*

A portion of the nitrogen and phosphorus required should be applied at seeding in one of two ways:

1. In a band 5 cm to the side and 5 cm below the seed. The rate of application in the band should not be more than 75 kg N/ha or a total of 120 kg of nitrogen-plus-potash ($K_2O$)/ha in 75-cm rows. If urea is the nitrogen source, not more than 40 kg nitrogen or 80 kg of nitrogen-plus-potash/ha should be applied, in 75-cm rows.
2. In a band directly with the seed. With this placement, not more than 9 kg nitrogen-plus-potash/ha should be applied, in 75-cm rows. Do not place urea with the seed. A major portion of the nitrogen should be applied preplant or side-dressed before the corn is 30 cm high. A major portion of the potash may be broadcast and worked in either in the fall or before seeding in the spring.

As phosphate does not move readily in the soil, and since it is required early in the plant's growth, it is best banded at the time of planting. As a result, there may be little need for the broadcast application of phosphate, depending upon the soil test rating.

### *Zinc*

Visual symptoms on the leaves are the best means of determining deficiency, but soil tests are also useful. Where zinc is required, it may be applied to the soil mixed in the fertilizer. Foliar-applied zinc is often an efficient way of correcting zinc deficiencies. See the section *Zinc*, on page 18, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

## Bird and Animal Management

### *Red-Winged Black Birds and Crows*

Acetylene exploders (bird bangers) are effective, but birds will soon resume feeding when exploders are not operating. For full effectiveness, start using the bangers before the corn becomes attractive for feeding and move them around frequently. Plant away from marshy and wooded areas. Cultivars with ears well-covered by husks are somewhat resistant to blackbirds.

Av-Alarm electronic bird-scaring devices have sometimes been used successfully to repel large flocks of birds from fields of sweet corn.

## Table 6–75.
## Sweet Corn Cultivars With Disease-Resistance Traits

| Type | Cultivar | Seed Company | Maturity (Days) | Pest Tolerance | | |
|---|---|---|---|---|---|---|
| | | | | Rust | Stewart's Wilt | Corn Borer/Earworm[1] |
| **Supersweet ($Sh_2$)** | | | | | | |
| Bi-colour | Starpak | Rupp | 78 | moderately resistant | resistant | |
| | BSS 0977 | Siegers | 78 | resistant | tolerant | resistant |
| | HMX 8344BS | Harris-Moran | 81 | moderately resistant | moderately resistant | |
| | Starship II | Seedway | 82 | tolerant | tolerant | |
| | Twin Star | Harris-Moran | 84 | moderately resistant | moderately resistant | |
| Yellow | Saturn | Seedway | 75 | tolerant | tolerant | |
| | GSS 0966 | Siegers | 78 | resistant | tolerant | resistant |
| | Envy | Seedway | 81 | tolerant | tolerant | |
| | Ultimate | Harris-Moran | 83 | | resistant | |
| White | Boreal VIP | Seedway | 78 | tolerant | tolerant | |
| | WSS1921 | Rupp | 82 | resistant | | |
| **Sweet Breed** | | | | | | |
| Bi-colour | Sweet Rhythm | Harris-Moran | 73 | | moderately resistant | |
| Yellow | Tuxedo | Stokes | 70–77 | moderately tolerant | moderately tolerant | |
| | Amaize | Rupp | 75 | moderately resistant | resistant | |
| | Empire | Rupp | 80 | resistant | | |
| | Incredible | Seedway | 83 | tolerant | tolerant | |
| | Sundial | Harris-Moran | 85 | moderately resistant | moderately resistant | |
| | Tablemaster | Johnny's | 85 | moderately tolerant | moderately tolerant | |
| | Tender Treat EH | Rupp | 95 | moderately resistant | moderately resistant | |
| White | HMX 5349WES | Harris-Moran | 77 | | resistant | |
| **Sugar Enhanced (Se)** | | | | | | |
| Bi-colour | Seneca Arrowhead | Rupp | 62 | | moderately resistant | |
| | Trinity | Johnny's | 68 | moderately tolerant | moderately tolerant | |
| | Native Gem | Rupp | 70 | moderately resistant | moderately resistant | |
| | Chippewa | Stokes | 70 | moderately tolerant | moderately tolerant | |
| | Seneca Nation | Seedway | 75 | tolerant | tolerant | |
| | Twilight | Seedway | 78 | | tolerant | |
| | BC 0801 | Siegers | 82 | resistant | tolerant | resistant |
| | Lancelot | Rupp | 82 | moderately resistant | moderately resistant | |
| Yellow | Merit | Seedway | 80 | | tolerant | |
| | Topacio | Harris-Moran | 85 | moderately resistant | moderately resistant | |
| White | Silver Princess | Seedway | 74 | tolerant | tolerant | |
| | Brilliance | Harris-Moran | 79 | moderately resistant | moderately resistant | |
| | Silver King | Rupp | 80 | | moderately resistant | |
| **Processing** | As recommended by processor. | | | | | |

[1] These varieties have been genetically enhanced to produce the same insect-controlling protein as is found in Bacillus thuringiensis.

## Disease Management

### *Three-Leaf Dieback*

Seedlings may die before or shortly after emergence, resulting in poor stand. Two fungi are responsible: *Penicillium* occurs as a contaminant on the seed, whereas *Pythium* is common in most soils. Seeds planted into cool soils and $Sh_2$ varieties are most susceptible.

To prevent three-leaf dieback, use one of the fungicide seed treatments listed in Table 6–76, *Sweet Corn Seed Treatments*, on page 141.

**Table 6–76.**
**Sweet Corn Seed Treatments**

| Trade Name | Active Ingredients | Rate | Pests Controlled | Notes |
|---|---|---|---|---|
| **Insecticide and Fungicide Combinations** | | | | |
| DCT | diazinon-captan-thiophanate-methyl | 125 g per 25 kg seed | seed maggots, seedling blights, including *penicillium spp.* | |
| Agrox B-3 | diazinon-lindane-captan | 85 g per 25 kg seed | seed and root maggots, wireworms, damping-off and seedling blights | Do not use on seed already treated with an insecticide. |
| Agrox D-L plus | diazinon-lindane-captan | 50 g per 25 kg seed | seed and root maggots, wireworms, damping-off and seedling blights | Use on seed previously treated with captan or thiram. Do not use on seed already treated with an insecticide. |
| DLC | diazinon-lindane-captan | 50 g per 22.7 kg seed | seed maggots, wireworms and seedling blights | Use on seed previously treated with captan or thiram. |
| **Fungicide Only** | | | | |
| Apron XL LS | metalaxyl-m | 20–40 mL per 100 kg seed | damping-off and root rot | For use in commercial seed treatment plants only. Tank-mix with Maxim 480 FS. |
| Maxim 480 FS | fludioxonil | 5.2–10.4 mL per 100 kg seed | damping-off, seedling blights, including *penicillium spp.* | For use in commercial seed treatment plants only. Tank-mix with Apron XL LS. |
| Captan FL | captan | 60–85 mL per 25 kg seed | seed decay, damping-off and seedling blights | For use in commercial seed treatment plants only. |
| Thiram 75 WP | thiram | 55 g per 25 kg seed | seed decay and damping-off | Do not feed treated clippings to livestock. |

### *Stewart's Wilt*

This disease is transmitted by the corn flea beetle. Yield losses are most significant when susceptible varieties are infected before the 7-leaf stage.

Mild winters favour flea beetle survival and increase the risk of problems the following season. There is no control for this disease, however many varieties have excellent resistance to the Stewart's wilt bacteria. Ask your seed company representative about disease susceptibility ratings.

### *Rust*

This fungal disease becomes noticeable towards the end of summer. Cool weather (16°C–23°C) with overnight dew favours disease progress. Epidemics arise from spores blown in by winds from infected corn crops south of the border. There is a range of rust resistance in sweet corn cultivars. Rust infections occurring after the plant has silked are unlikely to result in yield losses. If rust is present in the field prior to silking, apply one of the fungicides listed in Table 6–77, *Sweet Corn Insect and Disease Control Recommendations*, on page 142.

## Insect Management

### *Seedcorn Maggot and Wireworms*

Seedcorn maggot flies are attracted to fresh manure and rotting organic matter. Incorporate manure promptly to discourage egg-laying.

Reduce losses to seedcorn maggots and wireworms by promoting rapid germination (avoid planting unnecessarily deep and into cold soils.) Wireworms are most likely to be a problem for the first 2 years following sod.

For a list of registered seed treatments, see Table 6–76, *Sweet Corn Seed Treatments*, above.

### *Corn Flea Beetle*

These small (2 mm) black beetles cause elongated scratches on the leaves. This is rarely significant by itself, but the beetles can carry Stewart's wilt disease, which can cause significant losses. The risk is greatest in May and June, before the plants reach the 7-leaf stage. Mild winters increase beetle survival and increase the risk of Stewart's wilt transmission.

### *Cutworms*

Cutworms are an occasional, early-season pest of sweet corn. If monitoring indicates a problem, refer to Table 6–77, *Sweet Corn Insect and Disease Control Recommendations*, on page 142. Chemical controls are most effective if applied to moist soils in the late afternoon or early evening. For more information, see the section *General Insects and Diseases of Vegetable Crops*, on page 44.

### *Corn Rootworm*

Corn rootworm adults lay their eggs in the fall in corn fields. The following spring, emerging larvae will feed on corn roots. They weaken the root system, often causing

## Table 6–77.
## Sweet Corn Insect and Disease Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Rust** | | | | | | |
| propiconazole | triazole | Tilt 250 E | 500 mL | 200 mL | 14 | Under severe disease pressure, make second application in 14 days. |
| chlorothalonil | chloronitrile | Bravo 500 | 3.2 L | 1.3 L | 14 | Maximum 2 applications per year. |
| **European Corn Borer** | | | | | | |
| permethrin | pyrethroid | Pounce 384 EC | 275–375 mL | 110–150 mL | 1 | Aerial application permitted. |
| cypermethrin | pyrethroid | Cymbush 250 EC | 280 mL | 112 mL | 5 | Maximum 3 ground applications or 2 aerial applications per year. |
| | | Ripcord 400 EC | 175 mL | 70 mL | 5 | |
| carbaryl | carbamate | Sevin XLR plus | 2.5–4.0 L | 1–1.6 L | 1 | |
| carbofuran[2] | carbamate | Furadan 480 F | 1.1 L | 0.44 L | 7 | Maximum 2 applications per year. 48-hr re-entry period.[2] |
| methomyl | carbamate | Lannate SP | 625 g | 250 g | 3 | 24-hr re-entry period. |
| acephate | organophosphate | Orthene SP | 0.75–1.1 kg | 0.3–0.44 kg | 21 | Maximum 4 applications per year. |
| deltamethrin | pyrethroid | Decis 5 EC | 250–300 mL | 100–120 mL | 5 | Maximum 2 ground or 1 aerial application per year. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33.2 mL | 1 | Maximum 3 ground applications or 2 aerial applications per year. 24-hr re-entry period. |
| Bacillus thuringiensis | biological | Dipel 2X DF | 0.56–1.12 kg | 0.22–0.44 kg | | Apply when pinhole feeding is observed on 5% of plants. |
| **Corn Earworm, Fall Armyworm** | | | | | | |
| cypermethrin | pyrethroid | Ripcord 400 EC | 175 mL | 70 mL | 5 | Maximum 3 ground applications or 2 aerial applications per year. |
| permethrin | pyrethroid | Pounce 384 EC | 275–375 mL | 110–150 mL | 1 | Earworm. Aerial application permitted. |
| | | | 180 mL | 72 mL | 1 | Fall armyworm. Aerial application permitted. |
| deltamethrin | pyrethroid | Decis 5 EC | 250–300 mL | 100–120 mL | 5 | For earworm only. Maximum 2 applications per year. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33.2 mL | 1 | Maximum 3 ground applications or 2 aerial applications per year. 24-hr re-entry period. |
| methomyl | carbamate | Lannate SP | 430–625 g | 172–250 g | 3 | For earworm only. 24-hr re-entry period. |
| **Aphids** | | | | | | |
| pirimicarb | carbamate | Pirimor 50 DF | 550 g | 220 g | 3 | Ground application. 34–50 L of water/ha. |
| | | | | | 3 | Aerial applications. 20–45 L of water/ha. Maximum 1 application per year. |
| **Corn Rootworm** | | | | | | |
| carbofuran | carbamate | Furadan 480 F | 500 mL | 200 mL | 7 | 48-hr re-entry period. |
| **Cutworms** | | | | | | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33.2 mL | | Apply up to 5-leaf stage. 24-hr re-entry period. Do not disturb soil for 5 days after application. |
| permethrin | pyrethroid | Pounce 384 EC | 180–390 mL | 72–156 mL | | Apply up to 5-leaf stage. Do not disturb soil for 5 days after application. |
| cypermethrin | pythroid | Ripcord 400 EC | 175 mL | 70 mL | 21 | |
| chlorpyfrifos | organophosphate | Lorsban 4E | 1.2–2.4 L | 0.48–0.96 L | 70 | 24-hr re-entry period. |
| | | Pyrinex 480 EC | 1.2–2.4 L | 0.48–0.96 L | 70 | 24-hr re-entry period. |

[1] DHI = Days to Harvest Interval.

[2] If prolonged direct contact with corn foliage will occur, do not re-enter treated fields between 2–14 days of application without wearing appropriate protective clothing such as long pants and a long-sleeved shirt.

lodging (or goosenecking). Crop rotation will almost always control corn rootworm populations.

Adult beetles occasionally feed on corn silks in late July–early August, however populations are usually kept under control by corn borer and earworm sprays. Severe feeding may result in poor kernel set.

### *European Corn Borer*

This insect is a major pest of sweet corn in Ontario. Sweet corn is susceptible to corn borer from the late-whorl stage (12–14 leaves) until the silks dry. During these stages, fields should be inspected weekly for egg masses and/or pinhole feeding.

When pinhole feeding is observed on at least 5% of the plants, apply one of the insecticides listed in Table 6–77, *Sweet Corn Insect and Disease Control Recommendations*, on page 142. If the tassel has not yet completely emerged, direct sprays down into the whorl. After that time, direct the spray toward the ear zone.

Applications at 5–7 day intervals usually give satisfactory control. This interval may vary with temperature and material used (consult manufacturer's label directions). Pyrethroid insecticides break down rapidly when temperatures exceed 26°C.

To reduce the threat of major corn borer infestations, rotate your sweet corn planting with other crops and keep grassy weeds bordering fields and in ditch banks under control.

There are now transgenic varieties of sweet corn with the Bt gene, which gives them complete resistance to corn borers and partial resistance to earworms and fall armyworms, reducing the need for insecticides. Some insecticides may be needed for other pests if pressure is high. Check with your seed company representative for availability and planting restrictions.

For more information, refer to the OMAF Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

### *Corn Earworm and Fall Armyworm*

These two late-season pests do not overwinter in Ontario. They are carried by winds across the Great Lakes from the United States. Adult moths usually appear in late July to early August. The larvae of both species attack the ear, causing economic injury to late-planted sweet corn fields.

**Table 6–78.**
**Corn Earworm Spray Intervals**
Based on trap counts.

| | Daily Maximum Temperature | |
|---|---|---|
| **Moths/trap/week** | **Less than 27°C** | **More than 27°C** |
| 1–6 | 5–7 days | 5–7 days |
| 7–90 | 5 days | 4 days |
| More than 90 | 4 days | 3 days |

Both pests can be monitored with pheromone traps. Pheromone monitoring is particularly effective for the corn earworm; field scouting is almost impossible. Insecticide applications are based on the number of moths caught per week and the average temperatures. See Table 6–78, *Corn Earworm Spray Intervals*, above.

Sweet corn is only susceptible to corn earworm damage while the silks are green. For chemical control options, see Table 6–77, *Sweet Corn Insect and Disease Control Recommendations*, on page 142.

For more information, refer to the OMAF Factsheet, *Corn Earworm*, Order No. 95-065.

### *Aphids*

Repeated use of pyrethroid insecticides may increase the population of aphids by killing the beneficial insects that normally feed on them. To minimize aphid problems, only use pyrethroid insecticides when corn earworms or fall armyworms are present, or if the crop is within 1 week of harvest. If monitoring indicates a need, apply one of the insecticides recommended in Table 6–77, *Sweet Corn Insect and Disease Control Recommendations*, on page 142.

**Bee Warning**

Bees often visit sweet and field corn to collect water and pollen. Spraying may cause bee poisoning. Sevin, Furadan and Pounce are highly toxic to bees. Damage to bees is reduced when sprays are applied in early morning or late evening when bees are not foraging. Do not treat when the wind is blowing. Avoid spray drift to roadsides and adjacent fields where plants might be in bloom.

Advise local beekeepers of spraying activity (see the section *Prevent Bee Poisoning*, on page 6).

# TOMATOES

**Table 6–79.**
**Suggested Tomato Cultivars**

| Cultivar | Seed Company | Maturity (days) | Notes |
|---|---|---|---|
| **Fresh Market** | | | |
| Sunstart | Norseco | 58 | Tolerant to verticillium wilt (race 1) and fusarium wilt (race 1, 2). |
| Sunshine | Norseco, Seedway | 60–66 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2) and anthracnose. |
| Sunchief | Norseco, Seedway, Rupp | 66 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2) and anthracnose. |
| Sunbrite | Norseco, Seedway, Rupp | 68 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2) and anthracnose. |
| Florida 47 | Rupp | 72–74 | Tolerant to verticillium wilt (race 1) and fusarium wilt (race 1, 2). |
| Mountain Fresh | Harris-Moran, Rupp | 78 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2) and early blight. |
| **Paste** | | | |
| Aztec VFN | Stokes | 68 | Tolerant to verticillium wilt (race 1), fusarium wilt, nematodes and bacterial speck. |
| APT 533 | Stokes | 76 | Tolerant to verticillium wilt (race 1), fusarium wilt and nematodes. |
| Puebla | Seedway | 75 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2), nematodes and bacterial speck. |
| Hybrid 882 | Seedway | 72 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2), nematodes and bacterial speck. |
| **Cherry** | | | |
| STM 5403 | Seedway | 70 | Tolerant to verticillium wilt (race 1), fusarium wilt (race 1, 2), nematodes and bacterial speck. |

## Cultivars

The varieties listed in Table 6–79, *Suggested Tomato Cultivars*, above, highlight some of the disease-resistance traits available on the market. It is not a complete list. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. Check with a range of seed companies for additional recommendations and variety descriptions.

## Cultivars for Commercial Processing

Follow processors' requirements.

See the section *Vegetable Transplants*, on page 151, for information on producing tomato transplants.

## Plant Spacing

Table 6–80, *Plant Spacing for Tomatoes*, right, shows spacing for both fresh market and processing types of tomatoes.

### *Processing (Machine Harvest)*

Machine harvest–type varieties will benefit from a twin row system, grown on a flat or raised bed. If harvesting equipment will allow, planting a single row every 75 cm (30 in.) with the in-row plant spacings described in Table 6–80 will provide equivalent yields and may reduce foliage and fruit disease.

## Plasticulture for Fresh Market Tomatoes

Use of plasticulture will result in improved earliness, yield and quality of fresh market tomatoes. Plastic mulches warm the soil, conserve moisture and keep the fruit clean, thus reducing soil-borne fruit rots. Black plastic mulch is recommended because it also provides weed control. If plastic mulch is used, drip irrigation is recommended.

Some growers use hot caps or row covers to promote faster early season growth. They do not provide significant frost protection, but do speed growth. Monitor the temperature under the covers on warm, sunny days to ensure it does not exceed 32°C–35°C. Ventilation or removal may be needed. Remove row covers prior to blossom set, as they will interfere with pollination and fruit set. For more information, see the section *Plasticulture*, on page 33.

**Table 6–80.**
**Plant Spacing for Tomatoes**

| | Row Spacing | In-Row Spacing | Bed Centres |
|---|---|---|---|
| **Fresh Market** | | | |
| Large vined (indeterminate) | 1.5–1.8 m<br>(5–6 ft) | 50–70 cm<br>(20–27 in.) | |
| Small vined (determinate and semi-determinate) | 0.9–1.5 m<br>(3–5 ft) | 30–60 cm<br>(12–24 in.) | |
| **Processing (machine harvest)** | | | |
| Twin row system | 45 cm<br>(18 in.) | 45 cm<br>(18 in.) | 1.5–1.65 m<br>(5–5.5 ft) |
| Small vined (early maturing) | 45 cm<br>(18 in.) | 33 cm<br>(13 in.) | 1.5–1.65 m<br>(5–5.5 ft) |

### Table 6–81. Nitrogen Recommendations for Processing Tomatoes

| Soil Type | Hybrid | Open-Pollinated |
|---|---|---|
| Coarse sand and sandy loams less than 2% organic matter | 160–180 kg/ha | 100–120 kg/ha |
| Loams, silt loams and sandy loams more than 2% organic matter | 90–120 kg/ha | 70–90 kg/ha |

## Fertility

### *Nitrogen*

#### Fresh Market Tomatoes

Apply 35–50 kg nitrogen/ha preplant, followed by a side-dress application of 35–50 kg nitrogen/ha after the first fruit are set. Avoid late side-dress applications as this may prune roots and causes blossom-end-rot. If additional nitrogen is required late in the season, it may be injected through the irrigation system.

#### Processing Tomatoes

The nitrogen rate will vary greatly, according to the variety, soil type, crop rotation, organic matter and soil management. Nitrogen should be applied as a preplant broadcast application. Apply nitrogen according to the recommendations in Table 6–81, *Nitrogen Recommendations for Processing Tomatoes*, above.

> A cover crop should be seeded after harvest is completed; this will protect soil and reduce erosion. In addition, the soil will absorb and tie up left-over nitrogen fertilizer and reduce leaching.

#### Starter Solution (All Tomatoes)

Apply a high phosphorus starter fertilizer in the transplant water when transplanting tomatoes. Starter fertilizer is especially important when planting in cool soils in early spring. Starter fertilizers are available in several forms including liquids (10-34-0 or 6-24-6) or granular materials (10-30-20 or 10-52-10). Apply according to the recommendations in Table 6–82, *Starter Solution Recommendations for Tomatoes*, right.

### *Phosphate and Potash*

Soil tests should be used to determine phosphate and potash requirements. Phosphate and potash fertilizer should be applied as a broadcast application, prior to planting. On most soil types, a fall application of potassium and phosphorus is acceptable. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 14, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 15.)

### Table 6–82. Starter Solution Recommendations for Tomatoes

For sandy soils with less than 2% organic matter, use half the recommended rates.

| Soil Temperature | Starter Concentration |
|---|---|
| Less than 18°C | Use full label rate as recommended. |
| Between 18°C–27°C | Use half of recommended rate. |
| Greater than 27°C | Starter not normally required. |

### *Magnesium*

A magnesium deficiency may occur on tomatoes. The usual symptoms are yellowing of older leaves while the veins remain dark green. See the section *Micronutrients*, on page 16, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 16.

### *Blossom-End Rot (BER)*

This disease is a localized calcium deficiency in the blossom-end of the fruit that prevents proper development of that tissue. It occurs when dry soil conditions reduce the amount of water movement into the plant, thus reducing the movement of calcium to the fruit. Therefore, BER is caused primarily by drought, not by a deficiency of calcium in the soil.

Side-dressing with calcium nitrate will not prevent BER if adequate moisture is not available. Foliar sprays of calcium are also not effective, because most of the calcium is taken up and fixed in the leaves, and very little reaches the fruit. Under drought conditions, growers should avoid deep cultivation, which can prune roots and reduce moisture uptake, making BER more severe. Blossom-end rot can be controlled by irrigation, which allows more movement of calcium into the plant. (See the section *Irrigation*, on page 35.)

## Bird Management

### *Ring-Billed Gull Control*

Ring-billed gull populations are increasing and are moving further inland along the shores of Lake Erie and Lake Ontario. Tomato fruits are damaged by repeated feeding scars resulting in reduced yields and quality, and increased sorting costs. Overall population control is not feasible; however, growers wishing to protect areas within a field can obtain a licence to shoot gulls. Early gull detection and control are important. For a permit, call the Enforcement Coordinator, Canadian Wildlife Service, Environment Canada (905) 336-6410.

**Table 6–83.**
**Tomato Disease Control Recommendations**

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Bacterial Leaf Spot** | | | | | | |
| chlorothalonil *plus* copper sufate | chloronitrile & inorganic | Bravo 500 F | 2.8 L | 1.1 L | 1 | |
| | | *plus* Kocide 101 WP | 2.25 kg | 0.9 kg | | |
| mancozeb *plus* copper | dithiocarbamate & inorganic | Dithane DG | 2.25 kg | 0.9 kg | 7 | |
| | | *plus* Kocide 101 WP | 2.25 kg | 0.9 kg | | |
| | | Manzate DF | 2.25 kg | 0.9 kg | 7 | |
| | | *plus* Kocide 101 WP | 2.25 kg | 0.9 kg | | |
| copper hydroxide | inorganic | Parasol 50 WP | 2.25 kg | 0.9 kg | 1 | Should be combined with 1.75–2.25 kg/ha mancozeb. (7 days) |
| **Anthracnose, Early Blight, Late Blight** | | | | | | |
| captan | phthalimide | Maestro 75 DF | 3.0–4.5 kg | 1.2–1.8 kg | 2 | Anthracnose only. |
| | | Captan 80 WDG | 2.75–4.25 kg | 1.1–1.7 kg | 2 | Use high rate on mature plants. |
| chlorothalonil | chloronitrile | Bravo 500 F | 2.4–4.0 L | 0.96–1.6 L | 1 | Under heavy disease pressure, use higher rate. |
| mancozeb | dithiocarbamate | Dithane DG | 1.1–3.25 kg | 0.4–1.3 kg | 7 | |
| | | Dithane M-45 | 1.1–3.25 kg | 0.4–1.3 kg | 7 | Aerial application permitted. |
| | | Manzate DF | 1.75–3.25 kg | 0.7–1.3 kg | 7 | |
| | | Penncozeb 75 DF | 1.1–3.25 kg | 0.4–1.3 kg | 7 | |
| metiram | dithiocarbamate | Polyram 80 DF | 2.25–3.25 kg | 0.9–1.3 kg | 7 | Low rate for early and late blight; high rate for anthracnose. |
| **Septoria Leaf Spot** | | | | | | |
| chlorothalonil | chloronitrile | Bravo 500 F | 3.8 L | 1.5 L | 1 | |
| benomyl | benzimadazole | Benlate 50 WP | 850 g | 344 g | 7 | |
| captan | phthalimide | Maestro 75 DF | 3.0–4.5 kg | 1.2–1.8 kg | 2 | Use high rate on mature plants. |
| | | Captan 80 WDG | 2.75–4.25 kg | 1.1–1.7 kg | 2 | Use high rate on mature plants. |
| metiram | dithiocarbamate | Polyram 80 DF | 3.25 kg | 1.3 kg | 7 | |

[1] DHI = Days to Harvest Interval.

## Disease Management

### *TOM-CAST*

This is a program to help growers determine when to apply foliar fungicides in field tomatoes. It is designed for the control of early blight, septoria leaf spot and fruit anthracnose.

A network of mini weather stations is used to monitor conditions favourable to disease development. Stations are located throughout the processing tomato-growing regions of Southwestern Ontario. Disease severity values are calculated from the weather information for each day throughout the summer. Growers are advised to spray at critical values determined by the TOMCAST program. For more information, contact the Ontario Weather Network at (519) 674-1532.

*Note:* TOM-CAST is not available in some fresh market tomato-growing regions of Ontario. In these areas, use a preventative program using the fungicides recommended in Table 6–83, *Tomato Disease Control Recommendations*, above.

### *Bacterial Spot*

It is not possible to completely control this disease with chemical sprays. The most effective results have been achieved when applications are made early, before significant disease is observed.

If weather conditions are favourable for bacterial disease infections prior to the initiation of the fungicide spray program using TOM-CAST, choose one of the spray combinations recommended in Table 6–83, *Tomato Disease Control Recommendations*, above. Conditions favourable for bacterial spot include 24°C–30°C with free moisture on the leaves.

If moist, windy conditions prevail, repeat within 5 days of the initial bacterial control spray. If bacterial disease pressures continue after initiating the fungicide program, use one of the combination treatments following TOM-CAST (see the section *TOM-CAST*, left).

### Bacterial Canker, Bacterial Speck

Optimium conditions for bacterial speck are cool (18°C–24°C), moist weather, while bacterial canker prefers warm (24°C–32°C), wet weather. Bacterial speck infections can show up as a downward turning and wilting of the lower leaves, often only on one side of the plant. A reddish-brown discolouration may be seen in the vascular tissues of the stem. Stem cankers and "bird's-eye" lesions on the fruit may be present. Bacteria spread in the field cause the foliar blight symptoms. The leaves develop brown to black margins, which often curl upward, bordered by a thin, yellow band.

It is not usually possible to control these diseases in the field with chemical sprays. Seed-borne bacterial canker can be prevented with a hydrochloric acid seed treatment (see the section *Vegetable Transplants*, on page 151). There are no practical control measures for tomato bacterial diseases after they are found in the field. Clipping and handling transplants can spread disease.

**Note:** Avoid working in fields when foliage is wet. Wash machinery with a high pressure hose after working in contaminated fields.

### Anthracnose, Early Blight, Septoria Leaf Spot

Anthracnose is a common and serious disease affecting the tomato fruit. If uncontrolled, it can quickly cause severe losses in marketable fruit. It is a serious problem for processors, as it affects the taste of the product.

Early blight, alone or in combination with septoria leaf spot, can cause severe defoliation in a tomato crop. Septoria leaf spot can cause rapid defoliation and severe crop losses. It usually becomes prevalent after plants have begun to set fruit.

Properly timed fungicide sprays are effective at reducing losses due to these diseases. TOM-CAST is available to processing-tomato growers. Otherwise, spray when first fruits are about walnut size (or when first fruits appear on early cultivars). Repeat sprays as necessary. During continuous moist weather, intervals should be 5–7 days. In warm dry weather, intervals can be extended to 12–14 days if diseases are under control. For anthracnose, continue spraying until mid-September.

### Late Blight

Late blight has the potential to cause severe crop losses. It is usually only a concern mid-to-late season but is very weather dependent. Scout fields regularly to detect early problems. Control is best achieved with a preventative fungicide program that provides constant foliar protection, especially during wet weather.

If late blight is present and conditions are favourable (moisture and 21°C–26°C days and 10°C–15°C nights), follow a 5–7-day fungicide schedule. Growers following TOM-CAST will be informed if and when additional fungicide applications are required.

### Septoria Leaf Spot

If monitoring indicates a need, spray with one of the fungicides recommended in Table 6–83, *Tomato Disease Control Recommendations*, on page 146.

### Fusarium Wilt, Verticillium Wilt

A long crop rotation (4–6 years) is recommended to reduce populations of the *Fusarium* and *Verticillium* fungi in the soil. Grow cultivars resistant to fusarium wilt and verticillium wilt if suited to your area and market. Soil fumigation may be recommended if root lesion nematode and *Verticillium* populations are high enough.

### Viral Diseases (Mosaic, Streak, Grey Wall)

Ensure that transplants are healthy and certified disease-free. Do not handle tobacco in any form when handling plants. Wash hands with soap and water before handling tomato plants. Control weeds in and around the field. Do not harden transplants by leaving them in headlands or other weedy places. Properly clean machinery after using it in infected fields. Some viruses can survive in root debris. Use a minimum 2-year rotation between susceptible crops. Destroy infected plants found during transplanting and during the season.

The Western flower thrips (WFT) may occasionally vector the tomato spotted wilt virus (TSWV) to field tomatoes. The WFT is a small (1–2 mm) insect that can easily be confused with onion thrips. Regular and consistent monitoring for both thrips and potential virus symptoms in transplant houses and the field is necessary. No insecticides are labelled currently for thrips on field tomatoes. Consult the OMAF Factsheet, *Pest Management of Thrips on Greenhouse Vegetables*, Order No. 94-023.

## Insect Management

### Cutworms

Early-season species of cutworms can clip off transplants at the soil line, reducing stands. Variegated cutworms are problematic later in the season.

Early detection is essential for control, as larger insects are more difficult to control. Visually inspect 3 plants at 10 sites within the field and treat if one or more larvae per 30 plants is found. Alternatively, pheromone traps can be used to detect peak moth flights. Control measures are warranted when trap catches reach 7 moths per trap per week.

If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–84, *Tomato Insect Control Recommendations*, on page 149. Sprays are most effective when applied in the late afternoon or early evening.

### *Aphids*

Aphids are an infrequent problem in tomatoes. Hot, dry summers are favourable to their development. The potato aphid and the green peach aphid are the most common types of aphids found in tomatoes. Inspect 10 leaflets/plant on three plants at 10 sites within the field. If monitoring indicates a problem (more than 0.5 aphids/leaflet), spray with one of the pesticides recommended in Table 6–84, *Tomato Insect Control Recommendations*, on page 149.

### *Tarnished Plant Bug*

Tarnished plant bug (and stink bug) damage can be a problem for fresh market and whole pack tomato crops. If monitoring indicates a need, spray with one of the pesticides recommended in Table 6–84, *Tomato Insect Control Recommendations*, on page 149. For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

### *Colorado Potato Beetle*

Young Colorado potato beetle larvae are much easier to control than adult beetles. As a result, regular field scouting increases the effectiveness of foliar sprays. Visually inspect three plants at 10 locations in the field for adults and larvae. Treat the field or portion of the field if levels exceed 0.5 CPB/plant in the first 2 weeks after transplanting or 1 CPB/plant later in the season. Border sprays may provide adequate protection from migrating Colorado potato beetles in new tomato fields.

Warning: In a number of counties and regions, Colorado potato beetles have developed a strong resistance to a number of insecticides. To slow development of further resistance, it is essential for all growers to rotate between chemical groups each time a spray is applied. For more information on assessing resistance in your area, refer to the OMAF Factsheet, *Colorado Potato Beetle Dip Test*, Order No. 92-028.

### *Hornworm*

If hornworms are present and monitoring indicates a need (1 or more larvae per 30 plants), spray with one of the pesticides recommended in Table 6–84, *Tomato Insect Control Recommendations*, on page 149.

### *Sap Beetle*

Since there is no suitable insecticide to control sap beetles in the field, practise the following cultural controls to reduce the incidence of sap beetles in the fruit:

1. Make roadways in the field at suitable intervals to allow movement of farm vehicles.
2. Minimize crushing and squashing of fruit at picking time.
3. Pick as close as possible to time of delivery to the factory.
4. If loaded wagons are not delivered immediately, leave them exposed to air circulation rather than in a protected area.

### *Grasshopper and Cricket*

Maintain weed-free borders and fencerows. If these insects are a problem, spray around the edge of the field with one of the pesticides recommended in Table 6–84, *Tomato Insect Control Recommendations*, on page 149.

## Chemical Fruit Ripening

Use ethephon (Ethrel) for uniform ripening and once-over harvest and to enhance ripening in the late cultivars or during late seasons. For best results, ethephon should be applied to healthy fields. Plants that are stressed (wilted or damaged by disease or insects) will not respond satisfactorily. If plants are under stress, avoid use of ethephon or apply it at reduced rates.

Ethephon is only effective on mature green fruits. When cutting fruit with a sharp knife, seeds should remain uninjured and protected by a gelatinous pulp. With most processing cultivars, the time of application is when the maximum number of fruit has reached the mature green stage. This occurs when 5%–20% of the fruit is showing red colour development.

Good spray coverage on fruit and foliage is essential for maximum effectiveness. Use 3.75–6.4 L in 30–500 L of water/ha. Use the higher rates when day temperatures are below 18°C or when plant growth is dense. Excessive rates of ethephon will cause defoliation, which will result in reduced fruit quality. Cool temperatures will delay colour development and extend periods between treatment and harvest. Generally, fruit is ready to harvest 14–21 days after treatment.

**Ethrel is not registered for use on fresh market tomatoes.**

## Table 6–84.
## Tomato Insect Control Recommendations

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Cutworms** | | | | | | |
| permethrin | pyrethroid | Pounce 384 EC | 180–260 mL | 72–105 mL | 1 | |
| methomyl | carbamate | Lannate SP | 270–540 g | 109–218 g | 1 | If many large larvae (2.5–3.0 cm) are found, use the higher rate. 24-hr re-entry period. |
| carbaryl | carbamate | Sevin XLR plus | 1.25 L | 0.5 L | 2 | |
| acephate | organophosphate | Orthene 75 SP | 1.2 kg in 2,000 L of water | 0.48 kg in 800 L of water | 90 | Based on 14,000 plants/ha. Transplanting water treatment only. |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33 mL | 7 | Do not disturb the soil for 5 days after application. 24-hr re-entry period. |
| **Aphids** | | | | | | |
| diazinon[2] | organophosphate | Diazinon 50 WP | 1.0–1.75 kg | 0.4–0.7 kg | 1 | |
| | | Diazinon 500 EC | 1.1–1.7 L | 0.4–0.68 L | 1 | |
| | | DZN 600 EW | 0.915–1.4 L | 0.37–0.56 L | 1 | |
| dimethoate | organophosphate | Cygon 480 E | 0.5–1.1 L | 0.2–0.44 L | 7 | |
| | | Lagon 480 E | 0.5–1.0 L | 0.2–0.44 L | 7 | |
| malathion[2] | organophosphate | Malathion 25 W | 2.75–4.25 kg | 1.1–1.7 kg | 3 | |
| | | Malathion 500 E | 1.25 L | 0.5 L | 3 | Not effective below 18°C. |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 1.5–2.75 L | 0.6–1.1 L | 2 | |
| | | Endosulfan 50 W | 1.1–2.25 kg | 0.44–0.9 kg | 2 | |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 2 | |
| methomyl | carbamate | Lannate SP | 270–540 g | 109–218 g | 1 | Minimum period for re-entry is 24 hr. |
| acephate | organophosphate | Orthene 75 SP | 1.2 kg in 2,000 L of water | 0.48 kg in 800 L of water | 90 | Based on 14,000 plants/ha. Transplanting water treatment only. |
| **Tarnished Plant Bug** | | | | | | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33 mL | 7 | Minimum period for re-entry is 24 hr. |
| dimethoate | organophosphate | Lagon 480 E | 0.5–1.1 L | 0.2–0.44 L | 7 | |
| carbaryl | carbamate | Sevin XLR plus | 5.25–6.4 L | 2.1–2.6 L | 2 | |
| **Colorado Potato Beetle** | | | | | | |
| **Transplant treatment** | | | | | | |
| imidacloprid | chloronicotinyl | Admire 240 F | 0.85–1.3 L<br>7–10 mL per 100 m of row | 0.34–0.52 L<br>2–3 mL per 100 ft of row | | Applications can be made as a drench in the transplanting water or through application equipment set up exclusively to apply Admire. Consult label for details. Use only ONE application where CPB populations are high. |
| acephate | organophosphate | Orthene 75 SP | 1.2 kg in 2,000 L of transplant water | 0.48 kg in 800 L of water | 90 | Based on 14,000 plants/ha. **Caution:** temporary plant damage may occur on light sandy soils or if too high a rate is used. |
| **Foliar treatment** | | | | | | |
| azinphos-methyl | organophosphate | Guthion Solupak | 850 g | 340 g | 4 | 7 days between applications. Maximum 4 applications per year. 48-hr re-entry period. |
| | | APM 50 WP | 850 g | 340 g | 2 | |
| | | Sniper 240 E | 1.75 L | 0.7 L | 4 | |
| permethrin | pyrethroid | Pounce 384 EC | 180–260 mL | 72–105 mL | 1 | |
| cypermethrin | pyrethroid | Cymbush 250 EC | 140 mL | 56 mL | 3 | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83–125 mL | 33–50 mL | 7 | Use the higher rate for larger instars or higher populations of larvae. 24-hr re-entry period. |
| Bacillus thuringiensis | microbial | Novodor FC | 4.0–8.0 L | 1.6–3.2 L | 0 | Field scouting is essential for timing of sprays. |
| imidacloprid | chloronicotinyl | Admire 240 F | 200 mL | 80 mL | 7 | Maximum 2 foliar spray applications at least 5 days apart may be made per year. **Do not make a foliar application following a soil application of Admire in the same crop.** 24-hr re-entry period. |

## Table 6–84.
## Tomato Insect Control Recommendations (Continued)

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | DHI[1] | Notes |
|---|---|---|---|---|---|---|
| **Hornworm** | | | | | | |
| permethrin | pyrethroid | Pounce 384 EC | 180–260 mL | 72–105 mL | 1 | |
| carbaryl | carbamate | Sevin XLR Plus | 2.5–5.25 L | 1.0–2.1 L | 2 | |
| endosulfan | chlorinated cyclodiene | Thiodan 4 EC | 1.5–2.75 L | 0.6–1.1 L | 2 | |
| | | Endosulfan 50 W | 1.1–2.25 kg | 0.44–0.9 kg | 2 | |
| | | Thionex 50 WP | 1.1 kg | 0.44 kg | 2 | |
| Bacillus thuringiensis | microbial | Thuricide HPC | 0.75–1.5 L | 0.3–0.6 L | 0 | Most effective against small larvae. |
| | | Dipel 2XDF | 140–275 g | 56–110 g | 0 | |
| | | Biprotec CAF | 0.65–1.1 L | 0.26–0.44 L | 0 | |
| azinphos-methyl | organophosphate | Guthion Solupak | 0.85–1.12 kg | 0.34–0.45 kg | 4 | 48-hr re-entry period. 7 days between applications. Maximum 4 applications per year. |
| | | APM 50 WP | 0.85–1.12 kg | 0.34–0.45 kg | 2 | |
| | | Sniper 240 E | 1.75–2.25 L | 0.7–0.9 L | 4 | |
| cyhalothrin-lambda | pyrethroid | Matador 120 EC | 83 mL | 33 mL | 7 | 24-hr re-entry period. |
| **Drosophila (fruit fly)** | | | | | | |
| diazinon | organophosphate | Diazinon 50 WP | 1–1.75 kg | 0.4–0.7 kg | 1 | |
| | | Diazinon 500 EC | 1.1–1.7 L | 0.44–0.68 L | 1 | |
| | | DZN 600 EW | 0.915–1.4 L | 0.37–0.56 L | 1 | |
| naled | organophosphate | Dibrom EC | 1.1 L | 0.44 L | 4 | |
| azinphos-methyl | organophosphate | Guthion Solupak | 0.85–1.12 kg | 0.34–0.45 kg | 4 | 48-hr re-entry period. 7 days between applications. Maximum 4 applications per year. |
| | | APM 50 WP | 0.85–1.1 kg | 0.34–0.44 kg | 2 | |
| | | Sniper 240 E | 1.75–2.25 L | 0.7–0.9 L | 4 | |
| **Cabbage Looper** | | | | | | |
| Bacillus thuringiensis | microbial | Thuricide HPC | 2.0–4.25 L | 0.8–1.7 L | 0 | Most effective against small larvae. |
| | | Dipel 2XDF | 275–550 g | 110–220 g | 0 | |
| | | Biprotec CAF | 1.4–2.8 L | 0.56–1.12 L | 0 | |
| **Grasshopper, Cricket** | | | | | | |
| azinphos-methyl | organophosphate | Guthion 240 SC | 2.25 L | 0.9 L | 4 | 48-hr re-entry period. 7 days between applications. Maximum 4 applications per year. |
| | | Sniper 240 E | 2.25 L | 0.9 L | 4 | |
| | | Guthion Solupak | 1.12 kg | 0.45 kg | 4 | |

[1] Days to Harvest Interval.

[2] Control of aphids with diazinon and malathion has been inconsistent in many areas.

# VEGETABLE TRANSPLANTS

Transplants offer a number of advantages over direct seeding for many vegetable crops in Ontario. The level of management required for successful transplant production varies with the crop type. See Table 6–85, *Relative Ease of Transplanting Vegetables*, below.

## Trays

Most commercial vegetable transplants are grown in plastic trays, usually in the range of 30–288 cells per tray. Various types and sizes are available. For recommended tray sizes, see Table 6–86, *Suitable Tray Sizes for Various Vegetable Species*, right.

In general:

- Larger cells are used for early crops. They produce a larger, more mature transplant, resulting in earlier yields. They are more expensive to produce.
- Smaller cells are used for mid-to-late season crops. They are cheaper to produce, but smaller cell volume makes water and nutrient management critical.

## Disinfection

For transplants grown under contract, the terms may specify that new trays be used for each crop. In other cases, growers may choose to use trays for more than one season. Trays must be thoroughly sanitized before being reused. They must also be structurally and chemically able to withstand both the treatment and another season of handling.

There are two effective options to sanitize used trays:

1. **Solarization:** Stack trays and cover them with a cloth or plastic cover. Leave them in the greenhouse during the summer. The heat will super dry the disease organisms, while allowing some non-disease organisms to survive to act as biological control agents. Under this system, it is important to use trays with as square a cell as possible, to minimize the amount of growing media left in the trays from the previous use.
2. **Chemical Disinfectants:** Trays can also be individually washed to remove particles of growing media, then dipped or sprayed with a solution of D.C.D. or Virkon according to manufacturer's recommendations. Chlorine bleach can also be used. Be cautious with bleach as residues on the trays can damage the seedlings. Dipping bulk lots of trays into a cleaning solution has not proven successful.

**Table 6–85.**
**Relative Ease of Transplanting Vegetables**

| Easy | Characteristics |
|---|---|
| Beets, broccoli, cabbages, Brussels sprouts, chard, lettuce, tomatoes | Efficient in water absorption; rapid formation of new roots. |
| **Moderate** | |
| Eggplant, leeks, onions, peppers, celery, cauliflower | Young plants do not absorb water as efficiently, but new roots form quickly. |
| **Difficult** | |
| Muskmelons, watermelons, cucumbers, squash, sweet corn | Root system is easily injured during transplanting; resume growth slowly; require special care. |

## Media

Growing media need to be:

- sterile (free of insects, pathogens, nematodes, weed seeds)
- uniform
- well-drained

**Table 6–86.**
**Suitable Tray Sizes for Various Vegetable Species**

| Crop | Tray Size | Cells/ft$^2$ | Production Notes |
|---|---|---|---|
| Early-market tomatoes | 24 | 14 | Usually seeded in 288s or 406s and transplanted to large tray at first true leaf. |
| | 38 | 23 | |
| | 50 | 31 | |
| Mid-to-late season tomatoes | 128 | 78 | Direct seeded in tray. |
| | 288 | 175 | |
| Processing tomatoes | 200 | 122 | According to processor specifications. |
| | 288 | 175 | |
| | 406 | | |
| Early peppers | 50 | 31 | Transplant seedlings or direct seed in tray. |
| | 72 | 47 | |
| Mid-to-late season peppers | 128 | 78 | Direct seed in tray. |
| | 200 | 122 | |
| Early cole crops | 72 | 47 | Direct seed in tray. |
| | 98 | | |
| Mid-to-late season cole crops | 128 | 78 | Direct seed in tray. |
| | 200 | 122 | |
| Cucumbers, melons, squash | 24 | 14 | Direct seed in tray. Do not allow plants to elongate in the greenhouse. |
| | 128 | 78 | |
| Cooking onions | 200 | 122 | Direct seed in tray; seedlings should be clipped several times to produce a stocky transplant. |
| | 288 | 175 | |
| | 338 | | |

- lightweight
- convenient for storage and handling
- non-crusting
- able to hold water well
- free of large pieces of bark or twigs

Many commercially prepared soilless mixtures are available that meet these criteria. The commercial mixtures generally contain peat moss, perlite, vermiculite and a wetting agent. Some also contain fertilizer (nutrient charge). It is important to know the nutrient content of the growing media in order to manage the fertilizer program. The fertilizer content of different mixtures may vary greatly. Avoid mixtures containing slow-release fertilizer or high nutrient charges. They can restrict the flexibility of a fertilizer program.

## Seed

All vegetable seed should be treated with a fungicide to help prevent seed decay and damping-off. Refer to the individual commodity sections for a list of recommended chemical seed treatments. Hot water treatment is an effective, non-chemical method to reduce bacterial and fungal pathogens on the seed. It is particularly important for the control of bacterial diseases of tomatoes, peppers and cole crops. See the section *Hot-Water Treatment*, right.

## Seeding and Germination

Vegetable transplants are generally sown one seed per cell, usually at a depth of about twice their diameter. See Table 6–87, *Vegetable Transplant Requirements*, on page 153, for information on seed, temperature, pH and time required for producing various types of vegetable transplants.

## Growth and Development

It is difficult to raise multiple crops within the same greenhouse if they have different environmental requirements (temperature, ventilation, light, water, fertility). If possible, grow crops with dissimilar requirements in different areas of the greenhouse where they can be managed as required.

## Temperature

Vegetable crops vary in their response to temperature. The optimum day and night growing temperatures for a number of crops are listed in Table 6–87, *Vegetable Transplant Requirements*, on page 153. Warm-season vegetable crops such as tomatoes, peppers, eggplant and vine crops are susceptible to chilling injury when the transplants are exposed to temperatures above freezing, but below 10°C (50°F) for an extended period of time. Chilling causes stunting of growth and can have long-lasting effects on field establishment.

### Hot-Water Treatment

1. Place seed in a large cheesecloth bag; the bag should not be more than half full. Place bags of seed in a large container filled with warm water.
2. Stir the water and bags of seed continually to secure rapid penetration of heat to maintain uniform temperature in the seed lot. Be sure to use an accurate thermometer.

***Cabbages, Broccoli, Brussels Sprouts, Tomatoes, Peppers and Eggplant***

Soak seed for 25 minutes in water maintained at 50°C. Spread seed out to dry.

***Cauliflower, Kohlrabi, Kale and Summer Turnip***

Treat seed as above but for 15 minutes.

***Celery***

Treat seed at 48°C for 30 minutes.

***Tomatoes***

Tomato seed can be treated at 54°C for 25 minutes. Plant seeds within a few days of treating.

Tomato seed can also be treated by soaking dry seed in 3 parts of 0.6 Molar hydrochloric acid (i.e., mix 1 part acid with 19 parts of distilled water) for 1 hr with frequent agitation. Drain the acid, thoroughly rinse in distilled water and dry. A 0.1 Molar hydrochloric acid (available from scientific supply companies) can also be used to soak the seeds for 1 hr with frequent agitation and, in this case, the seeds can be dried without rinsing in water.

## Height Control

Excessive stem elongation can be caused by low light conditions as well as excessive heat, fertilizer or water. "Pillowing" is uneven growth that results from differences in air circulation and watering between cells within trays.

Temperature can be used in many crops to control plant height. Managing the day/night temperature fluctuations in the greenhouse can allow the transplant grower to control stem length. Night temperatures that exceed day temperatures retard growth. Lowering the temperature by 4°C–5°C (7°F–9°F) will usually give good height control. Avoid chilling temperatures with warm-season vegetable crops.

### Table 6–87. Vegetable Transplant Requirements

| Vegetable | Seed Required for 10,000 Transplants (g) | Seeding Depth (cm) | Germination Temperature (°C)[1] | | | Days to Germination[2] | Optimum Growing Temperature | | pH Tolerance | Time (weeks) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Opt | Max | | Day (°C) | Night (°C) | | |
| Broccoli | 57 | 0.6 | | 29 | | 4 | 16–21 | 10–16 | 6.0–6.8 | 4–7 |
| Brussels sprouts | 57 | 0.6 | | 27 | | 5 | 16–21 | 10–16 | 5.5–6.8 | 4–7 |
| Cabbages | 57 | 0.6 | 7 | 29 | 35 | 4 | 16–21 | 10–16 | 6.0–6.8 | 4–7 |
| Cauliflower | 57 | 0.6 | 7 | 27 | 29 | 5 | 16–21 | 10–16 | 6.0–6.8 | 4–7 |
| Celery | 28 | 0.15–0.3 | 16 | 21[3] | 21 | 7 | 18–24 | 16–18 | 6.0–6.8 | 10–12 |
| Cucumbers | 567 | 1.3 | 16 | 35 | 35 | 3 | 21–24 | 16–18 | 5.5–6.8 | 2–4 |
| Eggplant | 113 | 0.6 | 24 | 29 | 32 | 5 | 21–27 | 18–21 | 5.5–6.8 | 5–7 |
| Lettuce | 28 | 0.3 | 4.5 | 24 | 27 | 2 | 13–18 | 10–13 | 6.0–6.8 | 4 |
| Muskmelons | 567 | 1.3 | 24 | 32 | 35 | 3 | 21–24 | 16–18 | 6.0–6.8 | 3–5 |
| Onions | 85 | 0.6 | 10 | 24 | 35 | 4 | 16–18 | 8–15 | 6.0–6.8 | 8–12 |
| Peppers | 198 | 0.6 | 18 | 29 | 35 | 8 | 18–24 | 15–18 | 5.5–6.8 | 5–9 |
| Squash | 1,475 | 1.3–1.9 | 21 | 35 | 35 | 3 | 21–24 | 16–18 | 5.5–6.8 | 2–4 |
| Tomatoes | 85 | 0.6 | 16 | 29 | 29 | 5 | 18–24 | 15–18 | 5.5–6.8 | 5–8 |
| Watermelons | 1,475 | 1.3–1.9 | 21 | 35 | 35 | 3 | 21–27 | 18–21 | 5.0–6.8 | 2–4 |

[1] Germination may be possible for many vegetables at much lower or higher temperatures, but percentage, speed and uniformity of germination will suffer.

[2] Under optimum germination temperatures. Primed seed will germinate faster than unprimed seed under most conditions.

[3] Daily fluctuation to 16°C or lower at night is essential.

Restricting phosphate can also effectively restrain transplant growth in the greenhouse, but excessive phosphate restriction can retard new growth after field transplanting.

## Watering

### Water Quality

Prior to the growing season, it is advisable to have a detailed water analysis completed. The greenhouse fertilizer program may have to be adjusted according to the pH, bicarbonate level and nutrient content of the water supply. See Table 6–88, *Acceptable Ranges of Water Quality and Correction Methods*, on page 154. **If high-quality water is not available, an alternative water supply should be obtained.**

### Watering Transplants

Plug transplants should be watered thoroughly in the morning and "spot watered" as necessary in the afternoon. Avoid watering late in the day, as disease problems increase when plants remain wet overnight. Use chlorinated water if possible. Disease organisms can be present in ditch or well water. Water should be in the 15°C–20°C (59°F–68°F) range to prevent shocking the plants.

The amount and frequency of watering will vary depending on cell type, growing media, greenhouse ventilation and weather conditions. **It is important to water thoroughly and moisten the entire plug, to promote root growth to the bottom of the plug.** Allow the plug to dry down before watering, but do not let the plant wilt severely, as this will damage roots.

## Fertility

Vegetable transplants are usually fertilized with soluble fertilizer, applied in the irrigation water. See Table 6–89, *Analysis for Various Soluble Fertilizers*, on page 155, for a list of fertilizers commonly used in transplant production. Growers should use fertilizers that have most of the nitrogen in nitrate form. Avoid fertilizers with a high concentration of urea.

A high concentration of phosphate ($P_2O_5$) may promote excessive seedling elongation. Use a fertilizer with a low to medium phosphate concentration, or use a fertilizer with no phosphate for most feedings and apply a high-phosphate fertilizer once every four or five feedings to promote growth. Do not withhold phosphate completely, as this will delay field establishment.

Vegetable crops vary in their response to fertilizer, so the feeding program must be modified for different crops. See Table 6–90, *Fertility Guidelines for Vegetable Transplants*, on page 155.

**Table 6–88.**
**Acceptable Ranges of Water Quality and Correction Methods**

| Factor | Range | Correction |
|---|---|---|
| PH | 5.5–6.5 | Acid can be used to lower the pH. |
| Bicarbonate level | 60–100 ppm | Acid can be used to lower the bicarbonate reading. Every 60 ppm of bicarbonate needs 7 L of phosphoric acid (85%)[1] or nitric acid (67%)[2] per 100,000 L of water. |
| EC (Electrical conductivity) | <0.6 mmho/cm in straight water<br>1.0–2.0 mmho/cm with fertilizer added | The fertilizer program can be adjusted to maintain a safe EC. |
| Nitrate levels | Normally less than 20 ppm | Adjust the fertilizer program accordingly. |
| Sulfates | Normally 150–250 ppm | |
| Chlorides | Normally 20–400 ppm | |

[1] Use no more than 7 L of phosphoric acid per 100,000 L of water to avoid crop problems (stretching). Use nitric acid for neutralizing more than 60 ppm bicarbonate.
[2] Each 7 L of nitric acid will contribute 14 ppm of nitrate nitrogen to the irrigation water.

## Electrical Conductivity (EC)

The electrical conductivity of the final nutrient solution should be checked. The ideal range is 1–2 mmho/cm. Electrical conductivity meters are available from most greenhouse-supply companies. Approximate ECs for several different fertilizer materials are listed in Table 6–89, *Analysis for Various Soluble Fertilizers*, on page 155.

## Toxicities and Deficiencies

Nutrient deficiencies are seen more often than nutrient toxicities. Many growers are very cautious about over-fertilizing for fear of "burning" the roots or stems.

Transplants that are starved for phosphorus will show very definite purple colouration along the stem and underside of leaves. Plants that have too little nitrogen will have pale-green foliage. However, too much nitrogen will result in very white stems and dark-green leaves.

### *Hardening-Off*

Prepare transplants for the harsher environment of the field by hardening them off. This is especially important for early-season plantings. Reducing water supply and/or lowering temperatures can harden off vegetable transplants.

Warm season crops should not be hardened at temperatures below 13°C (55°F). Cool-season crops can be hardened at lower temperatures. Certain cole crops can be susceptible to "bolting" or "buttoning" in the field if the transplants are exposed to prolonged temperatures below 10°C (50°F).

Watering of the transplants can be reduced to let the plants wilt slightly, as part of the hardening process. Do not let plants wilt excessively. Increasing air movement around the transplants also assists in the hardening process.

Consider holding plants outside for several days before field planting. This allows them to become acclimated to field conditions while they are still in their trays. Select a location that is exposed to full sunlight but is protected from drying winds. Check plants regularly and water as required.

Do not harden off plants by withholding fertilizer, as this can result in nutrient deficiencies and delay field establishment.

### *Storage of Plug Transplants*

If field planting is delayed by rain and plug transplants must be held, it is important to monitor them closely to maintain plant health and vigour. Research has shown that, if properly stored, tomato transplants can be held for up to 2 weeks with little reduction in plant stand or vigour.

- Transplants can be returned to the greenhouse or stored outside.
- Elevate the racks to prevent root growth through the bottom of the plugs.
- Bring the plants inside if there is a risk of frost.
- Storage in an enclosed trailer or barn for more than 1 or 2 days may result in very soft, elongated plants.
- Fertilize if planting is delayed more than 5–7 days. See Table 6–90, *Fertility Guidelines for Vegetable Transplants*, on page 155.

**Table 6–89.**
**Analysis for Various Soluble Fertilizers**

| Fertilizer Analysis | Rate for 100 ppm N (g/100 L of water) | Parts per Million | | | EC mmho/cm[1] |
|---|---|---|---|---|---|
| | | N | P | K | |
| 20-20-20 | 50 | 100 | 43 | 83 | 0.40 |
| 20-10-20 | 50 | 100 | 21 | 83 | 0.60 |
| 20-8-20 | 50 | 100 | 17 | 83 | 0.75 |
| 17-5-19 | 59 | 100 | 12 | 92 | 1.00 |
| 15-5-15 | 67 | 100 | 14 | 83 | 0.70 |
| 14-0-14 | 71 | 100 | 0 | 83 | 0.85 |

[1] Electrical conductivity of a 100 ppm solution in micromhos. The EC values were determined with a conductivity meter using distilled water. The EC values obtained will vary depending on the background EC of the water source.

## Disease Management

Damping-off, caused by *Pythium*, *Rhizoctonia* and *Fusarium* fungi, may occur before or after seedling emergence. After the seedling stage, fungal, bacterial and viral pathogens are of concern in transplant production.

The primary means of controlling diseases on vegetable transplants is by seed treatment, sanitation and by managing the greenhouse environment to suppress disease development.

Certain transplant or greenhouse crops should not be raised in close proximity, as one may act as a source of disease or an alternate host for insect vectors. Avoid growing tomato transplants close to greenhouses used for flowers or greenhouse cucumbers. Pepper and tomato transplants should not be raised in the same greenhouse complex.

Fungicides registered for use on greenhouse vegetables are listed in Table 6–91, *Disease Control Recommendations for Vegetable Transplants in the Greenhouse*, on page 156.

For more information on managing disease, see the section *General Insects and Diseases of Vegetable Crops*, on page 44.

**Table 6–90.**
**Fertility Guidelines for Vegetable Transplants**

| Crop | Fertility Guidelines |
|---|---|
| Tomatoes | Very responsive to fertilizer, excess fertility will reduce transplant quality.<br>If feeding at every watering, use a fertilizer concentration of 50–100 ppm N, depending on the stage of development.<br>There may be some advantage to feeding less often at a higher concentration. |
| Peppers | Require more fertilizer than tomatoes.<br>If feeding at every watering, use approximately 100 ppm N and increase the concentration if feeding less often. |
| Cole crops | Do not require as much fertilizer as other crops. One application per week of 100–150 ppm N should be sufficient under most conditions. |
| Vine crops | Have a relatively short growing cycle compared to other crops. Use 100–150 ppm N at weekly intervals for a total of 2–4 applications. |

## Insect Management

Insects such as aphids and thrips may transmit disease into and within the greenhouse. Fungus gnats and shore flies can cause damage by larval feeding on seedling roots and by spreading damping-off organisms.

Monitor for thrips and aphids. Hang blue, sticky traps close to the seedling canopy. Indicator plants (such as potted petunia for tomato spotted wilt virus) can be placed at the ends of the greenhouse.

## Herbicide Injury

Greenhouses should be equipped with a sprayer dedicated to herbicides only and a separate sprayer for fungicides and insecticides. Contamination may cause serious damage to greenhouse plants.

Avoid spraying weeds outside of the greenhouse during the growing season. Herbicide mist or fumes may drift or be sucked into the greenhouse. Transplant trays that are left outside on headlands may be inadvertently sprayed. Trays that are stored near herbicides can also absorb fumes. Once contaminated, trays cannot be cleaned effectively.

## Table 6–91.
## Disease Control Recommendations for Vegetable Transplants in the Greenhouse

| Common Name | Group | Trade Name | Rate per Hectare | Rate per Acre | Notes |
|---|---|---|---|---|---|
| **Damping-Off, Fungus Root Rot** | | | | | |
| captan | phthalamide | Maestro 75 DF | 1.5 kg/1,000 L of water Apply 50–85 L of solution per 100 $m^2$ (1,076 $ft^2$) | | Crucifers, eggplant, peppers, tomatoes, celery. Soil drench treatment. |
| | | Supra Captan 80 WDG | 1.5 kg/1,000 L of water Apply 50–85 L of solution per 100 $m^2$ (1,076 $ft^2$) | | Crucifers, eggplant, peppers, tomatoes, celery. Soil drench treatment. |
| oxine benzoate | dithiocarbamate | No-Damp | 10 mL/L of water | | Vegetable seedlings. Damping-off. Soil treatment. |
| **Bacterial Spot** | | | | | |
| cupric hydroxide | inorganic | Kocide 101 | 2.25 kg/ha | 0.9 kg/ac | Tomatoes, peppers. Bacterial spot. Apply every 5 days as warranted, to a maximum of 5 applications over a 4-week period prior to transplanting. Do not re-enter treated area for 24 hours. |

# 7. Weed Management for Vegetable Crops

More that 50 vegetable crops are grown commercially in Ontario. Some are seeded, some transplanted, some are annuals and other crops are perennial, presenting a very diverse group of situations to manage weeds. Weed management involves all aspects of weed control in vegetable crops including herbicides, cultivation, hoeing, mulches, weed prevention, etc.

Perennial weeds are often a more severe problem in perennial horticultural crops such as asparagus. Quackgrass, bindweed, thistles, horsetail, dandelions, etc., should be controlled before these crops are planted.

Treatments listed in this publication are based on extensive research trials. Herbicides should not be used in cold frames or greenhouses unless specifically recommended.

Vegetable crops are often high-value crops. Weed competition is costly. Improper application of herbicides can also be costly. Sprayers used for hormone-type herbicides (2,4-D, etc.) should not be used to apply insecticides, fungicides or other herbicides on susceptible horticultural crops.

## Preplant Weed and Cover Crop Control

Cover crops and emerged weeds should be controlled before seeding or transplanting vegetable crops. This can be done with glyphosate at 0.75 to 3.5 L/ha (0.3 to 1.4 L/ac), a translocated systemic herbicide, with paraquat (GRAMOXONE) or diquat (REGLONE) at 3.0 to 5.5. L/ha (1.2 to 2.2 L/ac), both contact, non-systemic herbicides or with glufosinate ammonium (IGNITE) at 2.7 to 5.0 L/ha (1.08 to 2 L/ac), a minimal translocation, mostly contact, non-systemic herbicide. All four herbicides are non-residual. Glyphosate (ROUNDUP or TOUCHDOWN) can be used before planting any vegetable crops. Paraquat (GRAMOXONE) or diquat (REGLONE) are registered for preplant use on beans, beets, carrots, cole crops, onions, peas, potatoes, sweet corn and rutabagas. Glufosinate ammonium (IGNITE) is registered for preplant use on carrot, lettuce and onions only. See Table 7–7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.

The Stale Seedbed Technique involves preparing a seedbed early in the growing season and controlling emerged weeds several weeks later with glyphosate, GRAMOXONE, REGLONE or IGNITE. Seeding or transplanting vegetable crops is done trying to disturb the soil as little as possible to delay the emergence of a new crop of weeds. This allows the crop to establish well before the next flush of weeds.

Alternatively, a grower may choose to kill the cover crop or/and emerged weeds just before planting the vegetable crop and either till the area or leave the seedbed untilled.

Inter-row weeding with a contact herbicide such as paraquat at 3 to 5.5 L/ha (1.2 to 2.2 L/ac) (product) in 250 to 1,000 L/ha (100 to 400 L/ac) water) can be used as a rescue operation where other methods of weed control have failed. The herbicide is directed between the crop rows onto the emerged weeds. Use special low pressure (7 to 15 kPa) applicators such as dribble bars or vibra jets equipped with shields to prevent wetting the crop. This technique of weeding with paraquat is registered for use on beans, beets, carrots, cole crops, cucumbers, lettuce, onions, potatoes, sweet corn and tomatoes. See the section *Stale Seedbed and Inter-Row Weeding*, on page 195.

## Preplanting (PP) Treatments

Preplanting treatments are applied before the crop is sown or planted. Some of these herbicides kill seedlings soon after germination while others also kill weed seeds. Most herbicides used for these treatments must be thoroughly incorporated in the soil by cultivation soon after application. Check the label.

## Selective Preemergence (PRE or PPI) Herbicides

These materials prevent the emergence of many weed seedlings without reducing the crop stand. This type of material should be applied immediately after seeding or at least before the emergence of the crop. If these materials are applied after weeds have emerged, kill is usually poor. Best results are obtained with this method when conditions for weed seed germination are good.

## Selective Postemergence (Post) Herbicides

These chemicals are applied after the crop plants have sprouted or after the crop has been transplanted. Applied as directed, the weeds can be killed without injury to the crop. The weeds should be small for best results.

## Principles of Integrated Weed Management

Integrated weed management (IWM) uses all available weed control strategies in the best possible way to manage weed populations. Such strategies include cultural, mechanical and chemical methods of weed control. All these practices are components of an IWM system, and none of these control measures on their own can be expected to provide acceptable levels of weed control. Therefore, instead of relying on only one particular method of weed control, an IWM system uses a combination of methods to control weeds. By following the principles of an IWM system, we can reduce the use of herbicides and at the same time provide optimum economic returns to the grower.

## Cultural Methods of Weed Control

### *Crop Rotation*

Crop rotation involves alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound, long-term weed control program. Weeds tend to thrive with crops of similar growth requirements as their own, and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture, that is, growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc.).

### *Field Scouting*

Field scouting is a key component of an IWM system. It involves the systematic collection of weed and crop data from the field (weed distribution, growth stage, population, crop stage, etc). The information is used, in the short term, to make immediate weed management decisions to reduce or avoid economic crop loss. In the long term, field scouting is important for evaluating the success or failure of weed management programs and for making sound decisions in the future.

### *Cover Crops*

The inclusion of cover crops such as rye, red clover, buckwheat and oilseed radish or overwintering crops like winter wheat or forages in the cropping system can suppress weed growth. Fast-growing crops or crops exhibiting allelopathic properties can also suppress weeds. Highly competitive crops may be grown as short duration "smother" crops within the rotation. Additionally, cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop.

### *Intercropping*

Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds. However, the use of intercropping as a strategy for weed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs.

### *Nitrogen Fertility*

Nitrogen fertilizer can affect the competition between crops and weeds and in the subsequent crops. For example, nitrate is known to promote seed germination and seed production in some weed species. Nitrogen fertilization may result in increased weed growth instead of increased crop yield. Selective placement of nitrogen in a band can favour the crop over the weed. Use of legume residues as opposed to chemical nitrogen fertilizer to supplement the nitrogen needs of the crop can enhance weed suppression. Legume residues release nitrogen slowly with less stimulation of unwanted weed growth.

### *Planting Patterns*

Crop population, spatial arrangement and the choice of cultivar (variety) can affect weed growth. For example, studies have shown that narrow row widths and a higher seeding density will reduce the biomass of later-emerging weeds by reducing the amount of light available for weeds located below the crop canopy. Similarly, fast-growing cultivars can have a competitive edge over the weeds.

### *Tillage System*

Tillage systems alter the soil seedbank dynamics and depth of burial of weed seeds. Studies have found that almost 75% of the weed seedbank was concentrated in the upper 5 cm of soil in no-till fields. In the moldboard plow system, however, the seedbank is more uniformly distributed over depth. Other conservation tillage systems are intermediate to these two systems.

Weed seedling emergence is often more uniform from shallowly buried weed seeds and may result in better weed control. Weed seeds closer to the soil surface are more likely to be eaten or damaged by insects, animals, other predators and disease-causing organisms.

## Critical Period of Weed Control

The critical period of weed control is an important concept in IWM systems. This period has been defined as an interval in the life cycle of the crop when it must be kept weed-free to prevent yield loss.

This concept helps determine the most effective time for non-residual postemergent herbicide applications and reduces the practice of season-long residual herbicides and unnecessary late applications of herbicides. The critical periods are defined relative to a crop growth stage to account for soil, weather and seasonal variations. The critical period is based on a yield loss of less than 5% due to weed interference. In other words, the crop has to be weed-free during these stages to prevent a yield loss of more than 5%.

If weeds have been controlled throughout the critical period, the weeds that emerge later will not affect the yield and can be controlled prior to or immediately after harvest.

The critical period can vary depending on weather and growing conditions. Some research with corn and soybeans has indicated that the critical period may vary with soil type and tillage system and where the end of the critical period may be extended slightly later on clay soils or when using no-till tillage systems.

Horticultural crops are very sensitive to weed competition and need to be kept weed-free from planting, emergence or budbreak, until the end of their critical weed-free period. This differs slightly from the critical period for weed control but is useful for crops where soil-applied preemergent herbicides or cultivation are the main option for controlling weeds. If the crop is kept weed free for the critical weed-free period, generally no yield reduction should result. Again, weeds emerging after the critical weed-free period will not affect yield, but control efforts after this time may make harvest more efficient or reduce weed problems in subsequent years in perennial crops.

**Table 7–1.**
**Critical Weed-Free Period for Horticultural Crops**

| Crop | Critical Weed-Free Period |
|---|---|
| Beets | First 2–4 weeks after emergence |
| Cabbage, early | First 3 weeks after planting |
| Carrots | First 3–6 weeks after emergence |
| Cucumbers, pickling | First 4 weeks after seeding |
| Lettuce | First 3 weeks after planting |
| Onions | The whole season |
| Potatoes | First 4 weeks after planting |
| Squash | Early plantings compete better |
| Sweet corn | 3rd leaf tip to 10th leaf tip |
| Tomatoes, fresh | First 36 days after transplanting |
| Tomatoes, seeded | First 9 weeks after seeding |

### *Season-Long Weed Control Is Not Necessary*

Alternative methods of weed control are available for all tillage systems. Studies have shown that banding herbicides will increase profitability. For example, selective application of herbicides in 30-cm bands on 76-cm wide corn rows represented an approximate 60% reduction in total herbicide applied into the environment. When complemented with inter-row cultivation, weed control and crop yields were maintained with lower herbicide costs.

### *Economic Thresholds*

Weed economic thresholds help determine if weed density and interference are sufficient to justify control measures, i.e., if the yield loss avoided is greater than the cost of weed control. The time at which weeds emerge relative to the crop is a major determinant of yield loss. Early weeds that emerge at the same time as the crop cause more yield loss than weeds that emerge after the crop is established. For example, economic threshold studies conducted with redroot pigweed, ragweed and barnyard grass have found that the time of weed emergence in relation to the crop stage is more important than weed density when evaluating weed control options. Crop yield loss depends on the relative time of weed seedling emergence.

**Corn:** Corn tolerated a weed density of 4 plants/m of row when redroot pigweed emerged at the 6th leaf stage of corn but only 0.5 plants/m when they emerged at the 3rd leaf stage of corn.

Critical periods and economic thresholds, however, do not apply in the same way to weeds, such as black nightshade, that may reduce the quality of the crop. In such cases, the economic threshold may be zero.

## Managing Weeds Resistant to Herbicides

The resistance of weeds to herbicides is not a unique phenomenon. In fact, resistance to antibiotics, insecticides and fungicides is a worldwide problem that is not confined to any single pest category.

Confirmed cases of pigweed resistance to the Group 2 family of herbicides have been found in Ontario. Some of these pigweed are also resistant to Group 5. This report of resistance is in addition to an already extensive list of 212 weed species throughout the world that are resistant to at least one of the groups of herbicides listed in Table 7–3, *Herbicide Groupings for Ontario*, on page 190. In Ontario, resistance has been reported to Groups 2, 4, 5, 7 and 22. In Western Canada and the United States, resistance has developed to Groups 1, 2, 3, 4, 5, 8 and 9 (see Table 7–3, *Herbicide Groupings for Ontario*, on page 190).

**NOTE 1:** For control of a particular triazine-resistant species, select an effective non-triazine (non-Group 5) herbicide, or select a tank mix or premix with an effective non-triazine (non-Group 5) herbicide component (see Table 7–3, *Herbicide Groupings for Ontario*, on page 190).

**NOTE 2:** ***Group 2 ALS-resistant weeds*** Biotypes of pigweed have been found that are resistant to one or more of the Group 2 herbicides. Resistant strains are difficult to distinguish from susceptible types. For control of a resistant species, select an effective non-Group 2 herbicide, or select a tank mix or premix with an effective non-Group 2 herbicide component (see Table 7–3, *Herbicide Groupings for Ontario*, on page 190).

### Delaying Herbicide Resistance

Herbicide resistance results from a change in a weed population over time after repeated application of the same group of herbicides. The result is reduced weed control in the field. Resistance to different types of herbicides develops at different rates among weed species and populations. To prevent or slow the development of resistant weeds on your farm, take the following common-sense approaches.

#### *1. Identify and Monitor*

Resistant weeds do not look different. Therefore, they are hard to identify. Furthermore, weed "escapes" are common after herbicide application. Resistance does not usually become obvious until 10% to 30% of the population become resistant. Survey your fields regularly and apply the methods of diagnosing herbicide-resistant weeds to catch problems as they arise.

#### *2. Prevent the Spread of Weeds*

When entering or leaving a field, clean all implements. Do not allow resistant weeds to go to seed.

#### *3. Use Alternatives to Chemical Weed Control*

Combine mechanical weed control, such as rotary hoeing or cultivation, with chemical weed control where possible.

#### *4. Rotate Crops and Herbicides*

Rotate herbicide usage so that the same herbicide group is not used year after year. One of the easiest ways to rotate to a new herbicide group is to rotate to a new crop. Then use a herbicide from an alternative group. See Table 7–3, *Herbicide Groupings for Ontario*, on page 190, for help selecting herbicides from different groups. This preplanning will prevent the same herbicide group from being used too often. When it is practical, use tank or formulated mixtures where both active ingredients within the tank act to kill the same weed in a completely different way.

#### *5. Keep Records*

Keep accurate records of crop rotations and herbicide use in all your fields. It will be easier to plan long-term weed management strategies if you have good records.

#### *6. Communication*

Stay in touch with farmer organizations, extension specialists, agribusiness, friends and neighbours about resistance problems they are encountering. Let your government or industry representative know about any cases of resistance so he or she can take the appropriate action to prevent the spread of the weeds.

### Diagnosing Herbicide-Resistant Weeds

Before assuming that any weeds surviving a herbicide application are resistant, rule out other factors that might have affected herbicide performance. Those factors are misapplication, unfavourable weather conditions, improper timing of herbicide application and weed flushes after application of a non-residual herbicide. If resistance appears to be likely, check for the following:

1. Are other weeds listed on the product label controlled satisfactorily? Usually, only one weed species will show herbicide resistance in any given field situation. Therefore, if several normally susceptible weed species are present, reconsider factors other than herbicide resistance.
2. Did the same herbicide or herbicides from the same group (see Table 7–3, *Herbicide Groupings for Ontario*, on page 190) with the same site of action fail in the same area of the field in the previous year?
3. Do your records show extensive use of the same herbicide or herbicides from the same group year after year?

If one or more of these three situations applies, it is possible that the weeds are resistant to the herbicide. If resistance is suspected, control the weeds with a labelled herbicide from another group or use appropriate non-chemical weed-control methods to prevent the weeds from going to seed. Next, contact your weed specialist, herbicide supplier and the appropriate chemical company to develop a comprehensive weed-control program to manage the problem.

For more information on herbicide resistance, see http://weedscience.com/.

## Mechanical Methods of Weed Control

### Preemergent or "Blind" Harrowing

Blind harrowing consists of waiting until after the crop has been planted, the seed is sprouted and the shoot is about to emerge. At this crucial time, the field is harrowed to kill the small weed seedlings that have already sprouted. The crop will emerge shortly afterwards, having gained a head start on the next generation of weeds. When properly carried out, this method can be most effective in controlling annual weeds in large seeded crops. In cereals, this blind harrowing will often provide adequate control of annual broadleaf weeds. In row crops, it can be used to keep weeds down until the crop plants are large enough to withstand other mechanical control methods. Any type of light harrow can be used. Blind harrowing must not be done on crops underseeded with grass or legumes.

### Weeder Harrow

A weeder harrow has spring tines that are gentle enough not to harm the cultivated crop, while uprooting or covering the smaller annual weeds. Therefore, the relative size of the cultivated plants and the weeds is important. Weeder harrowing will be most successful when used as a "blind harrowing." Specially designed weeder harrows have been developed for use on field crops at various stages of development. They can be used most effectively on field vegetables, corn, soybeans and cereals.

### Rotary Hoe

The rotary hoe has "fingers" that lift and mix the soil, uprooting small weeds. It is important to work at 10–20 km/h for satisfactory results. Best results are obtained during late morning or afternoon hours when the hot sun can dry out the uprooted weeds. Also, crop plants tend to be more pliable at this time, and injury is reduced. Rotary hoes tend to cause less crop damage than harrows. They are also effective in breaking up a soil crust and mixing surface-applied herbicides into the soil, which will improve the weed control. On light soils or under loose soil conditions, care must be taken to keep the rotary hoe working at a shallow depth.

### Inter-Row Cultivation

Shallow inter-row cultivation or scuffling of row crops uproots small weeds and cuts off larger weeds. Various types of equipment can be used but, when shovels are used, allow for up to 50% overlap for thorough weed control. Shields should be used to protect small crops.

Row cultivation can be used profitably when applying herbicides. The herbicide may be more effective and the amount of herbicide used can be reduced, particularly with band applications. To provide adequate weed control in long-season crops, such as corn, scuffling will probably have to be done more than once. The first cultivation is the most crucial since weeds that escape this pass will usually grow to maturity. Here again the relative size of the crop to the weeds is important and probably the limiting factor in achieving 100% success. Blind harrowing, weeder harrows and rotary hoes are used first so that inter-row cultivators produce good results.

## Mowing

Mowing or cutting weeds may control weeds in orchards, roadsides, lawns, etc. Harvesting hay or cereal crops also helps control weeds. Mowing cereal stubble in early August can reduce weed growth and weed seed production, especially if the cereal had been underseeded to another crop such as red clover to compete with the new weed growth. The best time to mow perennial weeds is usually at the bud stage when root reserves are low and before seed set. Note that if a herbicide application is planned for later in the season, adequate time should be left for weed regrowth after mowing. For more information, see the individual crop sections in Chapter 6, *Crop Management Recommendations*, on page 47.

## Use of Chemicals to Control Weeds

Chemicals may be used to control weeds either selectively in crops or non-selectively for the control of perennial weeds or on land not in crops, such as roadsides, fencerows and areas difficult to cultivate. The treatments listed in this publication are based on extensive field trials and observation on farms. Herbicides should not be used in cold frames or greenhouses unless specifically recommended.

### Time of Herbicide Treatment in Crop Areas

The susceptibility of both crops and weeds to herbicides is related to the time of application. Therefore, it is important to use the chemical at a time when the crop is at its maximum resistance and the weeds are at their maximum susceptibility. This time will vary depending on the crop involved and the herbicide used. Terms describing the times at which herbicides may be applied, unless specified differently, refer to the stage of development of the crop plants.

#### *Preplanting Treatments*

Preplanting (PP) treatments are applied before the crop area is sown or planted. Some herbicides used in this way act on germinating seedlings, others may also kill weed seeds. When used preplanting, some herbicides must be thoroughly incorporated (PPI) with the soil soon after application. Directions for incorporation are given throughout this publication where these herbicides are recommended.

#### *Preemergence Treatments*

Chemicals used in preemergence (PRE) treatments are applied after seeding but before the specified weed or crop emerges. The chemicals may control weeds by (1) killing weed seedlings and/or (2) establishing a toxic layer of chemical on or near the soil surface in which germinating seeds and young seedlings cannot survive.

For successful preemergence treatments, the crops must either be tolerant of the chemical at the seedling state or the toxicity must have disappeared before the crop emerges.

A smooth, well-prepared seedbed that is free of clods is necessary for best results. The surface soil should also be moist and the temperature favourable for the rapid germination of weed seed.

#### *Postemergence Treatments*

Postemergence (POST) treatments are applied after the crop and weeds have emerged. A selective chemical is used and the weeds are killed with little damage to the desirable plants. The types of weeds that may be controlled depend on (1) the susceptibility of the weed, and (2) the tolerance of the crop to the chemical. Treatment at the correct stage of crop development is important. Since most weeds are more susceptible to chemicals when young, early treatments will require less herbicide and will result in less damage to crops from weed competition and from spray equipment.

Sometimes a herbicide may be applied postemergence to the crop but preemergence to the weeds. For example, a crop may be cultivated, then a herbicide applied to the weed-free soil to control germinating weeds.

### Chemical Weed Control in Non-Crop Areas

#### *Treatment with "Soil Sterilants"*

Perennial weeds may be killed and the growth of annual weeds prevented by the use of soil-active chemicals, which are toxic to most plants. These "soil sterilants" may be applied at any time. Best results are obtained if application is followed by a period of rainfall.

#### *Treatment With Translocated Chemicals*

In eliminating perennial weeds, heavier dosages of 2,4-D and of other translocated chemicals must be applied than would normally be used in crop land. Mixtures of 2,4-D with other chemicals may be used to keep areas free of vegetation.

### *Treatment With Contact Chemicals*

These chemicals are not selective but kill all foliage they contact. While this will kill annual weeds, regrowth usually develops from the roots or crowns of perennial plants.

## Conservation Tillage

All herbicides recommended for use in specific crops in the conventional tillage sections of this publication can be used in conservation tillage systems provided they are used according to the labelled uses and the labelled rates.

**Minimum Tillage** involves very little use of tillage equipment for seedbed preparation. The soil, however, is tilled prior to seeding, resulting in somewhat rough planting conditions by conventional standards. There is very little living vegetation and a crop residue cover of more than 20% after seeding. Weed control in this cropping system is similar to weed control in conventional tillage. Preplant incorporated herbicide treatments may not be practical if crop residues are heavy. Good uniform soil mixing is required to produce satisfactory results with incorporated herbicides. If this condition cannot be achieved without extra tillage, then the preferred method would be to use preemergent or postemergent herbicides. Use inter-row cultivation with herbicides. Burn-down treatments are not normally required.

**Ridge Tillage** involves seeding the crop directly into the ridge formed by aggressive cultivation the previous year. The ridge planter skims off 2–5 cm of soil, crop residue, weeds and weed seeds from the top of the ridge and deposits these in the hollows between the rows. Preplant incorporated treatments are impractical with this system. This system is well suited to broadcast and/or banded applications of preemergent or postemergent herbicides. Excellent results have been obtained by band-applying preemergent herbicides at planting time to fresh, moist soil directly behind the seeding unit on the planter. Also, timely cultivation between crop rows while, at the same time, spraying the crop row with postemergent herbicides can provide excellent weed control. The ridging procedure that follows provides additional mechanical weed control. Proper adjustment of the ridge planter and early cultivation after seeding may eliminate the need for a burn-down treatment. (A burn-down treatment may be required prior to crop emergence if cultivation is delayed after seeding.)

**Strip Tillage** suggests that only narrow bands of soil in the seeding area are tilled by either power-driven rotovators or fluted coulters. The area between rows is left untilled, and the crop residue is undisturbed. Success with preplant incorporated treatments depends on the amount and type of residue, the nature of the specific herbicide and the tilling device used. Row middles are not usually cultivated but could be if appropriate equipment is available for inter-row cultivation. Usually, broadcast application of preemergent or postemergent herbicides is used. Band applications could be used if inter-row cultivation is an integral part of the production system. If vegetation is present at seeding time, a burn-down treatment is necessary.

**No-Till** cropping systems are the most demanding with regards to weed control. The crop is seeded directly into untilled soil with no follow-up cultivation. Weed control depends entirely on herbicides. Burn-down treatments are almost always required. Preemergent and postemergent herbicides are used to control weeds throughout the entire growing season. Crop residues may intercept a portion of preemergent herbicide. If rainfall is sufficient to wash the herbicide from the crop residue into the soil, weed control results will be satisfactory. However, if dry conditions follow application, results could be very disappointing. Postemergent foliar-applied herbicides are more appropriate under dry conditions.

### *Weed Population Shifts*

Weed population shifts is a term that refers to the changes in the kinds of troublesome weeds that occur with a change in tillage systems. When tillage is reduced, the environment of weed seeds and underground parts of perennial weeds is altered. These environmental alterations affect weed species differently. Deep burial of weed seeds under conventional tillage systems enforces seed dormancy and increases the life of seeds, perpetuating weed problems. Reducing tillage keeps more weed seeds at the soil surface where they are subject to the ravages of nature. Greater percentages of seed at the soil surface are destroyed before they germinate (by winterkill, birds, insects or rodents). Most seeds that do survive germinate sooner and, if they are controlled, they do not return seeds to the soil. If good weed control is obtained in the early years of reduced tillage, eventually the weed seeds in the soil become fewer, reducing the potential of serious weed problems that originate from seed. Pressure from annual weeds tends to decline after a few years in reduced tillage. On the other hand, reduced tillage favours weeds that reproduce from underground roots and stems; these underground parts are not mechanically injured or destroyed in reduced tillage systems. Perennial and biennial weeds tend to be more troublesome in ridge-till, strip-till and no-till fields. In reduced-tillage fields, these weeds emerge earlier and do not spread as much as they do in conventionally tilled fields. This allows more appropriate timing for spray application and more spot treatments. The most effective herbicides are foliar-applied systemic types that translocate well to underground plant parts before the above-ground parts are killed. When non-selective herbicides are used, perennial and biennial weeds must be treated between crops or the crop must be sacrificed in treated areas.

Burn-down treatments are meant to kill existing vegetation before crops emerge. Burn-down treatments may be required in minimum tillage, especially when cover crops are used; in ridge-till when seeding is delayed and/or when winter annual, biennial or perennial weeds are present; and almost always in no-till and strip-till fields. Vegetation can be killed by:

- contact herbicides like paraquat
- translocated systemic herbicides like glyphosate, dicamba or 2,4-D
- residual herbicides that have postemergence foliar activity such as atrazine, linuron or metribuzin plus surfactants or oils and
- a contact or systemic herbicide tank-mixed with a residual herbicide such as paraquat + atrazine or glyphosate + dicamba.

All of these treatments are most effective on young, actively growing plants. Coverage is extremely important with contact treatments. Burn-down treatments do not necessarily provide residual weed control.

When dense, vigorous growing vegetation is present just before or at planting time, large amounts of soil moisture are removed by that vegetation. This can be an advantage during springs when there is an over-abundance of soil moisture but is a definite disadvantage during springs when dry conditions prevail. Because of this situation, consideration should be given to early application of burn-down herbicides, perhaps even the previous fall when perennial cover crops or sod fields are involved. Under dry conditions, a rapid-acting burn-down would be preferred over a slower-acting treatment.

## Applying Herbicides

An exterminator's licence may be required by people applying herbicides on property other than their own domestic property. An operator's licence is required by a person operating an extermination business. For further information, contact any Ministry of the Environment and Energy Regional Office or the Ministry of the Environment and Energy Pesticides Section, 135 St. Clair Avenue West, Toronto, M4V 1P5.

Successful chemical weed control requires the application of the correct quantity of herbicide uniformly over the area. With selective weed control in field crops, this application becomes a precision operation.

The chemical is applied as an emulsion, solution or suspension. The volume of the mixture used per hectare depends on the herbicide and the crop being treated. Generally, low volumes (50–200 L/ha) are used when 2,4-D chemicals are sprayed on emerged weeds, and higher volumes (150–300 L/ha) when preemergence herbicides are applied.

Small areas may be treated with a garden sprayer or even with a watering can, if care is taken to wet all foliage.

Power equipment is necessary for larger areas. Equipment used for applying 2,4-D–like chemicals should not be used later for applying other solutions to 2,4-D–susceptible crops or garden plants.

# Notes on Herbicides for Vegetables

## Introduction

These notes should be considered with the recommendations given in the specific crop sections later on in this chapter, starting on page 194. Additional information on use, toxicity and safety precautions is given here. With a few exceptions, the herbicides are listed under their common (generic) rather than their trade or product name. See Appendix A, *Pesticides Used on Vegetable Crops in Ontario,* on page 271, to determine the corresponding common name for a particular trade name. For example, Appendix A indicates that the trade name AATREX has a common name of atrazine; notes on AATREX will be listed under atrazine in this section. See also the section *Notes on Adjuvants for Vegetables*, on page 185, for information on adjuvants used with vegatable herbicides.

Complete information on each herbicide is available on the product label that is located on the herbicide container. The federal Pest Management Regulatory Agency also lists pesticide labels on its Internet Web site at http://64.26.129.82/search/queryhit.htm. Many herbicide manufacturers also list product labels and/or Material Safety Data Sheets (MSDS) on their Web sites, which are listed in Appendix B, *Pest Control Product Companies*, on page 281.

## 2,4-D

**Trade Names:** 2,4-D AMINE, ESTEMINE (AMINE), ESTASOL (L.V.ESTER), IPCO 2,4-D, AMINE 600, SAVAGE. **Chemical Family:** Phenoxy. **Crop and/or Non-Crop Registrations**: Cereals, turf, pastures, non-crop land, asparagus, field corn, cranberries, raspberries, strawberries, bearing fruit trees including apples, pears, peaches, plums, apricots and cherries, water weeds and brush. **Sensitive Weeds:** Most broadleaf weeds and brush. **Uptake and Translocation:** Readily absorbed through leaves or roots. Translocated primarily in phloem with the sugars but can also move with water in the xylem. Accumulation is primarily in the young, rapidly growing meristematic regions of roots or shoots. **Basis of Selectivity:** Differences in interception, penetration, translocation, metabolism and sensitivity of active sites lead to greater activity on broadleaf weeds compared to grasses. **Application Methods:** Postemergence (broadleaf weeds), stem-foliage or stem-basal (brush). **Residual Activity:** Half-life in soil is usually not longer than 1 or 2 weeks during the growing season due to rapid decomposition by soil micro-organisms. **Unique Characteristics:** All weeds are more easily killed when growing rapidly in moist soil. Unfortunately, some broadleaf crops, garden and ornamental plants are as sensitive to 2,4-D as many weeds and only a trace of the chemical as spray drift, vapour drift or contaminant in soil or water may cause serious damage. Even crops that can be sprayed safely can be sensitive at some stages of growth or at excessive application rates; thus label precautions should be followed carefully. Amines and esters are the most common formulations of 2,4-D. The esters are the most active and can be used at the lower rates and for brush control. Since vapour drift is a potential problem with the ester formulations, only the amines should be used on lawns or near gardens or susceptible crop areas. Low-volatile esters can be used by agriculturists or licenced applicators in areas where risk of damage to sensitive non-target vegetation is low. Recommendations are on the basis of acid equivalent; commercial products differ in their content of acid equivalent, which must be considered in determining the amount of product to use.

## ADJUVANT

See the section *Notes on Adjuvants for Vegetables*, on page 185.

## AMITROLE

**Trade Name:** AMITROLE 240. **Chemical Family:** Triazole. **Crop and/or Non-Crop Registrations:** Preplant in wheat, barley, canola, field peas, corn, soybeans and white beans. Post-harvest after any crop. In-season weed control in apples. Use in shelterbelts, non-crop areas, marshes and ditches. Spot treatment in pastures. **Sensitive Weeds:** Many annual and perennial broadleaf weeds and grasses, including quack grass, dandelions, Canada thistle, sow-thistle, poison-ivy, poison-oak, toadflax, milkweed, hoary cress, leafy spurge, horsetail, cattail, honeysuckle, locust, ash and sumac. **Uptake and Translocation:** Absorbed by foliage and roots. Translocates well in xylem and phloem. Accumulates in growing regions of plant. **Basis of Selectivity:** Resistant plants metabolize amitrole more rapidly than sensitive plants and may have lower uptake as a result of leaf structure that reduces wetting and penetration. **Application Methods:** Foliar postemergence application to actively growing plants. Good coverage is essential. If weeds are mature, it is advisable to cut them and then spray the regrowth. Do not disturb treated plants for at least 2 weeks after application. Do not make post-harvest application after October 1. For control of quack grass and Canada thistle, apply in spring or fall to actively growing plants 15–20 cm tall: wait 10–14 days and then plough or disk. **Residual Activity:** Approximately 2–4 weeks in moist, warm soil. **Unique Characteristics:** Most crops are sensitive if contacted. Poor results may occur if spray coverage is inadequate, if plants are drought stressed or overmature, or if heavy rains fall within 6 hours after application. Do not graze or plant to grain, peas, alfalfa or clover for 8 months after treatment. Do not graze spot-treated areas in pastures for 6 months following treatment.

## ATRAZINE

**Trade Names:** AATREX, AATREX NINE-O, ATRAZINE 90W, ATRAZINE 80W, ATRAZINE 500, ATRAZINE 480, CONVERGE 480. **Chemical Family:** S-triazine. **Crop and/or Non-Crop Registrations:** Corn (ensilage, field, seed and sweet), lowbush blueberries and triazine-tolerant canola (rapeseed). **Sensitive Weeds:** Will control a wide range of broadleaf weeds such as mustards, purslane, ragweed, smartweed, lady's-thumb, wild buckwheat, lamb's-quarters, pigweed and volunteer clover. Populations of lamb's-quarters, pigweed and ragweed have been found that are resistant to atrazine and are therefore not controlled. **Uptake and Translocation:** Actively absorbed by roots and foliage, although foliar absorption is usually small. It is translocated to the top of the plant and accumulates in the leaf margins and the growing points. **Basis of Selectivity:** Metabolism by tolerant species. Spray timing avoids contact with lowbush blueberries to prevent injury. **Application Methods:** For corn, preplant incorporated, preemergence or postemergence (with or without oil) usually before the annual weeds are more than 4 cm high; under dry weather conditions, a shallow incorporation may enhance activity; oil or oil/surfactant blends will increase the postemergence activity. For lowbush blueberries, preemergence application. For triazine-tolerant canola, postemergence. Dry bulk fertilizer may be impregnated with atrazine and applied preplant incorporated. Atrazine may be tank-mixed with several other annual grass and broadleaf herbicides to increase the spectrum of weed control in corn. **Residual Activity:** Can persist in the soil for varying lengths of time depending on rate, weather and soil conditions (longer under dry, cool weather conditions and in sandy soils). Postemergence treatments tend to persist longer than preemergence treatments. See the section *Special Notes for Sweet Corn*, on page 247. **Unique Characteristics:** Atrazine may carry over for more than one planting season. One year after application there is usually no hazard to most rotational crops when 1.5 kg ai/ha or less is applied. See Table 7–5, *Herbicide Crop Rotation and Soil pH Restrictions – Horticultural Crops*, on page 192. Cool, dry weather and sandy soils are conditions under which problems may arise.

## BENSULIDE

**Trade Name:** BETASAN. PREFAR. **Chemical Family:** Benzenesulfonamide. **Crop and/or Non-Crop Registrations:** Lawns, turf and cucumbers. **Sensitive Weeds:** Germinating annual grasses such as annual bluegrass, barnyard grass, crab grass and foxtail. Some control of redroot pigweed, lamb's-quarters and shepherd's-purse. **Uptake and Translocation:** Adsorbed on root surfaces, and a small amount is absorbed by the roots. Little or none is translocated upward to the leaves. **Basis of Selectivity:** Inhibits root growth and partially inhibits cell division in sensitive seedlings. Sensitive species affected only in seedling stage. Metabolized by established grasses. **Application Methods:** Preemergence in spring or fall for turf (well-established only); a higher rate is required for fall applications to control germinating weeds the following spring; incorporate by lightly irrigating into soil. **Residual Activity:** Season-long weed control. Degraded slowly by soil micro-organisms with a half-life of 4–6 months depending on soil type. Because of soil residues, only cucurbits, cole crops, carrots, lettuce, peppers and tomatoes should be planted the following year. **Unique Characteristics:** Bensulide is inactivated in soils containing high amounts of organic matter (muck soils). Incorporation recommended to avoid photodecomposition. Do not reseed lawn within 1 year of application. Formulations available with fertilizers for homeowner lawn use.

## BENTAZON

**Trade Names:** BASAGRAN FORTE, BASAGRAN. **Chemical Family:** Benzothiadiazine. **Crop and/or Non-Crop Registrations:** BASAGRAN FORTE AND BASAGRAN: Peas, flax, soybeans, dry beans, faba beans, corn. BASAGRAN also registered for peanuts, lima beans, snap beans, highbush blueberry, new plantings of apples, apricots, cherries, peaches, pears and turf. **Sensitive Weeds:** Annual broadleaf weeds including hairy nightshade, lamb's-quarters, redroot pigweed, low cudweed, purslane, common ragweed, wild radish, Russian thistle, hairy galinsoga, corn spurry, bird rape, flower-of-an-hour, buttercups, common groundsel, jimsonweed, giant ragweed, velvetleaf, lady's-thumb, wild mustard, cocklebur, stinkweed, shepherd's-purse and common chickweed. Triazine-tolerant biotypes of lamb's-quarters, redroot pigweed, common ragweed and common groundsel are also controlled. Top growth of Canada thistle and nut sedge are controlled. Field bindweed may be suppressed by two applications applied 10 days apart. **Uptake and Translocation:** Taken up through the foliage. Not translocated. **Basis of Selectivity:** Metabolism by tolerant species. **Application Methods:** Postemergence when weeds are small and actively growing. Apply in 100–400 L water/ha. Crop must be in a tolerant growth stage (see specific recommendations on label). Thorough spray coverage is necessary. Use flat fan nozzles tilted 45° forward. Use ASSIST OIL CONCENTRATE with BASAGRAN. The ASSIST rate should be reduced under hot, humid conditions. CITOWETT PLUS may replace ASSIST on peas. Liquid ammonium sulphate or 28% urea ammonium nitrate may be added to BASAGRAN FORTE or BASAGRAN for improved and more consistent control of velvetleaf and lamb's-quarters in soybeans only. PINNACLE may be tank-mixed with BASAGRAN FORTE or BASAGRAN for improved pigweed and lamb's-quarters control in soybeans only. BASAGRAN FORTE does not require additional adjuvants. BASAGRAN FORTE is not registered for aerial application. BASAGRAN is registered for aircraft application for soybeans, dry and snap beans. **Residual Activity:** Essentially none. **Unique Characteristics:** Corn and turf are tolerant at all stages of growth. Bentazon is not volatile. Temporary crop injury can be expected if bentazon is applied during hot, humid weather or if crop is stressed (flooding, drought, cold). Cool weather or drought may delay control. Rainfall within 6–8 hours after application may reduce effectiveness. Since there is no residual activity, a new flush of weeds may emerge after the first flush has been controlled.

## BENTAZON/ATRAZINE

**Trade Name:** LADDOK. **Chemical Family:** Benzothiadiazine/s-triazine. **Crop and/or Non-Crop Registrations:** Corn (ensilage, field, seed and sweet). **Sensitive Weeds:** Annual broadleaf weeds such as black nightshade, redroot pigweed, lamb's-quarters, low cudweed, purslane, common ragweed, Russian thistle, corn spurry, flower-of-an-hour, lady's-thumb, wild mustard, hairy galinsoga, bird rape, buttercup, common chickweed, common groundsel, jimsonweed, giant ragweed, velvetleaf and cocklebur. Triazine-tolerant biotypes are also controlled. Top growth of Canada thistle and nut sedge are controlled. Field bindweed may be suppressed. **Uptake and Translocation:** Uptake into the plant occurs primarily through the leaves. Bentazon/atrazine has mainly contact action and translocation is minimal. **Basis of Selectivity:** Metabolism by tolerant species. **Application Methods:** Bentazon/atrazine should be applied early postemergence when weeds are small and actively growing. Apply in 200–400 L water/ha. Application should be made before weeds reach the maximum size listed on the label. This generally corresponds to corn in the 1- to 5-leaf stage. Under good growing conditions, the most effective time for spraying will usually be 18–28 days after planting. ASSIST OIL CONCENTRATE should be added to the spray tank for all applications. Thorough spray coverage is important, and flat fan nozzles should be used. The use of flooding nozzles is not recommended because of inadequate coverage. **Residual Activity:** Injury may occur to any crop other than corn planted in the same season on land treated with bentazon/atrazine. In the season after application, there is virtually no hazard to most rotational crops when label rates for annual weed control have been used. Overlap or the use of a double application for nut sedge control may result in injury to rotational crops due to carry over of the atrazine component of bentazon/atrazine. **Unique Characteristics:** Corn is tolerant at all stages of growth. Rainfall within 6–8 hours of application may reduce effectiveness of the spray solution. Bentazon/atrazine is not volatile but it should not be applied when crop is under stress from prolonged cold, wet weather, poor fertility or other factors.

## BROMOXYNIL

**Trade Name:** PARDNER, KORIL. **Chemical Family:** Hydroxybenzonitrile. **Crop and/or Non-Crop Registrations:** Spring wheat, barley, oats, corn, fall rye, triticale, forage sorghum and millet, and many other grasses, garlic. **Sensitive Weeds:** Smartweed, nightshade, velvetleaf, pigweed, common ragweed, cocklebur, stinkweed and wild mustard are killed if the chemical thoroughly contacts these plants before they have more than 4 true leaves; wild buckwheat and lamb's-quarters control to 8 leaf. Most established perennial broadleaf weeds, chickweed and grasses tolerate field applications of this herbicide. **Uptake and Translocation:** Absorbed by plant foliage and moves very little within the plant. **Basis of Selectivity:** Differential spray retention, uptake, translocation and degradation. **Application Method:** Postemergence. **Residual Activity:** Essentially no soil residual activity. **Unique Characteristics:** Crop injury symptoms (leaf scorch) may develop if the plant is under stress within 2 or 3 days before or after spraying; this stress could be caused by high temperatures or high humidity or, in the case of corn, application following a period of cool, wet weather; such injury usually does not affect yields. The formulation includes a wetting agent to improve the spread of droplets on the leaf. Although bromoxynil is not an effective soil-applied herbicide, broadleaf crops such as turnips, peas and beans should not be seeded for a week after spray application.

## CHLORPROPHAM

**Trade Names:** CIPC EC, CIPC GR, CIPC. **Chemical Family:** Phenylcarbamate. **Crop and/or Non-Crop Registrations:** Carrots, lettuce, onions, spinach, daffodils, gladioli, iris, tulips and ornamental nursery stock. **Sensitive Weeds:** Annual broadleaf and grass weeds including purslane, chickweed, smartweed, carpetweed, false flax, annual bluegrass, crab grass, rye grass, stink grass and dodder. **Uptake and Translocation:** Readily translocated to the leaves following root absorption. Vapours have been demonstrated to be absorbed by seeds and emerged dodder. **Basis of Selectivity:** Rapid degradation in tolerant plants as well as soil adsorption. **Application Methods:** Preemergence and directed postemergence in specified crops. **Residual Activity:** Tightly bound to soil colloids. The rate of dissipation can vary greatly with microbial activity and moisture level. Both high soil temperature and excessive soil moisture increase the rate of dissipation. **Unique Characteristics:** Use the lower rates on sandy or coarse-textured soils and the higher rates on clay or muck soils. Weed control is most effective when soil temperatures are below 16°C. The lower rate should be used when soil temperature is below 16°C. The soil must be moist for effective weed control.

## CLETHODIM

**Trade Name:** SELECT. **Chemical Family:** Cyclohexanedione. **Crop and/or Non-Crop Registrations:** Canola, flax, soybeans, sunflowers, dry onions and potatoes. **Sensitive Weeds:** Annual grasses (wild oats, green and yellow foxtail, volunteer cereals, volunteer corn and barnyard grass). **Uptake and Translocation:** Uptake through the foliage and translocated through both the phloem and xylem throughout the plant accumulating in the meristemic regions both above and below the ground. **Basis of Selectivity:** Tolerant plants rapidly metabolize clethodim to several conjugated metabolites. **Application Method:** Postemergent to actively growing grasses in the 2- to 6-true-leaf stage. **Residual Activity:** Rapid degradation in both soil and water with no soil activity. **Unique Characteristics:** Highly active on all annual grasses and volunteer cereals at one low dose rate of 0.19 L/ha in a tank mix with the adjuvant CC-16255.

## CLOPYRALID

**Trade Names:** LONTREL 360, TRANSLINE. **Chemical Family:** Pyridine. **Crop and/or Non-Crop Registrations:** Strawberries, highbush blueberries, new and bearing apples, cranberries, sugarbeets, rutabagas, cole crops (cabbages, cauliflower, broccoli, Asian cole crops), canola, barley, oats, wheat, control of broadleaf weeds in rights-of-way (hydro, railroad, communication lines, pipelines) and associated stations, industrial manufacturing sites, storage sites and roadsides, airports, military bases and low maintenance, rough-turf areas, rangeland, grass pasture and balsam fir Christmas tree stands or plantations. **Sensitive Weeds:** Will control or suppress certain annual and perennial weeds including Canada thistle, goldenrod, ox-eye daisy, tufted vetch, sheep sorrel, dandelion and wild buckwheat, scentless chamomile, groundsel, ragweed, coltsfoot and spotted knapweed. **Uptake and Translocation:** Rapidly absorbed by foliage and translocated readily throughout the plant via both xylem and phloem systems. Clopyralid is distributed throughout the plant to the meristem. **Basis of Selectivity:** Effects on nucleic acid metabolism and growth are not observed in grasses and other tolerant species. **Application Methods:** Postemergence as a broadcast or selective foliar. **Residual Activity:** Half-life in soil is less than 30 days under conditions that are favourable for microbial degradation. Little to no residual activity. **Unique Characteristics:** Clopyralid has little to no activity on woody vegetation, except woody species of the legume family.

## COPPER ETHANOLAMINE

**Trade Name:** CUTRINE-PLUS. **Chemical Family:** Mixture of chelates of copper ethanolamines. **Crop and/or Non-Crop Registrations:** Algae control in wholly enclosed farm, fish and fire ponds and fish hatcheries having no outflow beyond the property limits of the user. **Sensitive Weeds:** Microcystis, Oscillatoria, Anabaena, Aphanizomenon, Spirogyra, Cladophora, Vaucheria, Ulothrix, Chara and Nitella. **Uptake and Translocation:** No information available. **Basis of Selectivity:** Non-selective. **Application Methods:** Available as a granular or liquid formulation. Apply early in the day as ample sunlight is required for maximum control. To ensure even distribution of the granular formulation, employ a scoop or dry fertilizer spreader. Use a hand or power sprayer for best distribution of the liquid formulation. To avoid oxygen depletion, treat only one-third to one-half of the pond at a time. Allow 1–2 weeks between treatments. **Residual Activity:** One application of granular CUTRINE-PLUS should provide control over the entire season. When using liquid CUTRINE-PLUS, a second treatment later in the season may be required. **Unique Characteristics:** Not for use in potable waters. Not for use in public waters or waters that drain into public waters. Extremely toxic to fish in soft waters; toxic in hard waters if the maximum recommended concentration is exceeded; if fish are present but water hardness is not known, do not use CUTRINE-PLUS. Treated areas may be used for swimming or fishing immediately after treatment. Water from treated pools may be used to irrigate turf, fairways, putting greens and ornamental plants.

## CYANAZINE

**Trade Names:** BLADEX LIQUID, BLADEX 90DF. **Chemical Family:** S-triazine. **Crop and/or Non-Crop Registrations:** Corn (ensilage, field and sweet), triazine-tolerant canola (rapeseed). **Sensitive Weeds:** Annual nightshades, purslane, lady's-thumb, lamb's-quarters, prostrate knotweed, shepherd's-purse, wild buckwheat, wild mustard, wormseed mustard, velvetleaf, pigweed, crab grass, green foxtail, yellow foxtail, witch grass, fall panicum and barnyard grass. **Uptake and Translocation:** Readily absorbed by roots and foliage. When absorbed by roots it is translocated to the leaves. **Basis of Selectivity:** Metabolism by tolerant crops. **Application Methods:** Preplant incorporated in corn but only in mixtures with other corn herbicides; incorporation equipment should be set to work no deeper than 10 cm. Preemergence in corn; moisture is required for activation. Early postemergence in corn up to the 3-leaf stage (wettable granule). Early postemergence in triazine-tolerant canola (liquid formulation). **Residual Activity:** Cyanazine has a relatively short residual life in the soil; from normal spring applications there is no carryover of the herbicide to the next growing season. **Unique Characteristics:** Cyanazine is a short-lived triazine herbicide with flexible application time. Preemergence applications do not adequately control barnyard grass, fall panicum or pigweed under conditions that delay germination, such as low temperature or dry soil surface. Emerged velvetleaf will be controlled by the early postemergence application but subsequent germinating velvetleaf will not be controlled. Cyanazine is not recommended alone for use on heavy clay soil. Do not use on peat, muck soils, sandy soils or soils with less than 1% organic matter. Do not use the liquid formulation postemergence in corn. Do not add oil or surfactants other than as specified on the label. Cyanazine may be used in tank mixes and has been formulated with various other herbicides. See label for specifications.

## CYCLOATE

**Trade Name:** RO-NEET. **Chemical Family:** Thiocarbamate. **Crop and/or Non-Crop Registrations:** Red beets, spinach. **Sensitive Weeds:** Crab grasses, barnyard grass, foxtails, yellow nut sedge and some annual broadleaf weeds. **Uptake and Translocation:** Uptake by seed, roots and hypocotyl with upward translocation to the growing tip. **Basis of Selectivity:** Species differentiation due to enzymatic detoxification and seed food reserves permitting seedling to outgrow effect of chemical. **Application Methods:** Preplant incorporated. To prevent chemical loss, incorporate immediately into the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator with sweep teeth or vibrating shank S-tine cultivator) to work the soil approximately 10 cm deep followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are done in separate operations, application should be to a dry soil surface. **Residual Activity:** Season-long weed control with no soil residues the following year to prevent crop rotation. **Unique Characteristics:** Does not need rainfall to activate and will not leach significantly under heavy rainfall. Under unfavourable germination conditions, leaf crinkling or leaf sealing may be observed, but usually without adverse effects on crop yield.

## DAZOMET

**Trade Name:** BASAMID. **Chemical Family:** Dithiocarbamate. **Crop and/or Non-Crop Registrations:** Field and greenhouse vegetable seedbeds for eggplant, lettuce, peppers and tomatoes; fall treatment only of tobacco greenhouse seedbeds; field and greenhouse seed and planting beds for annual flowers; turf seedbeds. **Sensitive Weeds:** Most germinating weed seeds. **Uptake and Translocation:** Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds. **Basis of Selectivity:** Non-selective. Chemical must be completely dissipated from the seedbed before planting or injury may occur. Breaks down on contact with soil moisture and releases toxic gases that control germinating weed seeds. **Application Methods:** Apply granular product to a well-worked seedbed and incorporate evenly. Seal soil immediately after incorporation by rolling and flooding or by covering with heavy polyethylene plastic and sealing edges. After a waiting period of 10–40 days, depending on soil temperature, aerate the soil. Conduct a safety germination test before using treated soil. Do not use when soil temperature is below 6ºC. **Residual Activity:** Depends on the rate applied, soil moisture and soil temperature. The gases are toxic to all growing plants and a safety germination test must be carried out to determine that the soil is safe for planting. **Unique Characteristics:** Also controls unencysted nematodes and soil fungi.

## DESMEDIPHAM

**Trade Name:** BETANEX. **Chemical Family:** Phenylcarbamate/Phenylcarbamate. **Crop and/or Non-Crop Registrations:** Sugarbeets. **Sensitive Weeds:** Redroot pigweed, lamb's-quarters and wild mustard. Other weeds like ragweed species, wild buckwheat, nightshade species, kochia, goosefoot and stinkweed will be controlled when application of desmedipham is made following treatment with another preplant or preemergence herbicide. **Uptake and Translocation:** Desmedipham is readily absorbed by foliage where it inhibits photosynthesis in the chloroplasts of leaf cells. **Basis of Selectivity:** Rapid metabolism in tolerant species. **Application Methods:** Postemergence beginning at the 2-true-leaf stage of sugarbeets. Up to the 2- or 4-leaf stage of weeds depending upon species. Best control is exhibited on very small, actively growing weeds. **Residual Activity:** Soil half-life of desmedipham is less than 1 month. **Unique Characteristics:** Desmedipham may cause temporary growth retardation and/or chlorosis or tip-burn to sugarbeets when applied to stressed plants. Normal growth is resumed in 10 days after application.

## DESMEDIPHAM/PHENMEDIPHAM

**Trade Name:** BETAMIX. **Chemical Family:** Phenylcarbamate. **Crop and/or Non-Crop Registrations:** Sugarbeets. **Sensitive Weeds:** Pigweed species, lamb's-quarters, wild mustard, wild buckwheat, green and yellow foxtail. Other weeds like ragweed species, nightshade species, kochia, goosefoot and stinkweed will be controlled when application of desmedipham/phenmedipham is made following treatment with another preplant or preemergence herbicide. **Uptake and Translocation:** Desmedipham/phenmedipham is readily absorbed by foliage where it inhibits photosynthesis in the chloroplasts of leaf cells. **Basis of Selectivity:** Rapid metabolism in tolerant species. **Application Methods:** Postemergence beginning at the 2-true-leaf stage of sugarbeets. Up to the 2- or 4-leaf stage of weeds depending upon species. Best control is exhibited on very small, actively growing weeds. **Residual Activity:** Soil half-life of desmedipham is less than 1 month and of phenmedipham is 25–30 days. **Unique Characteristics:** Desmedipham/phenmedipham may cause temporary growth retardation and/or chlorosis or tip-burn to sugarbeets when applied to stressed plants. Normal growth is resumed in 10 days after application.

## DICLOFOP-METHYL

**Trade Name:** HOE-GRASS 284. **Chemical Family:** Aryloxyphenoxypropionate. **Crop and/or Non-Crop Registrations:** Potatoes, white beans, kidney beans, carrots, onions, snap beans, soybeans, rapeseed (canola), lima beans, wheat barley, mustard, alfalfa, clover, peas. **Sensitive Weeds:** Barnyard grass, foxtails, witch grass, fall panicum, wild oats, volunteer corn. **Uptake and Translocation:** Primarily through the leaves. Does not translocate significantly. **Basis of Selectivity:** Differential metabolism by tolerant vs. sensitive species. **Application Methods:** Postemergence when grass weeds are in the 1- to 4-leaf stage. **Residual Activity:** Essentially none. **Unique Characteristics:** Tank mixtures with broadleaf herbicides will result in reduced weed control. A time interval of 4 days before or after an application of diclofop-methyl is required.

## DIMETHENAMID

**Trade Name:** FRONTIER. **Chemical Family:** Chloroacetamide. **Crop and/or Non-Crop Registrations:** Corn, dry beans and soybeans. **Sensitive Weeds:** Green and yellow foxtail, barnyard grass, fall panicum, witch grass, large and smooth crab grass, redroot pigweed and eastern black nightshade. **Uptake and Translocation:** Absorbed through shoots and roots of germinating grass and broadleaf weeds but primarily via plant coleoptile. **Basis of Selectivity:** Not established. **Application Method:** 1) Preplant incorporated — incorporate with vibrating shank cultivator, harrow or other implement capable of giving uniform shallow incorporation into the top 5 cm of the soil within 7 days of planting; 2) Preemergence — rainfall is required within 10 days of appliation to achieve sufficient herbicide activation; 3) Early postemergence (corn only) — apply at the spike to 2-leaf stage of corn and up to the 2-leaf stage of annual grass weeds. **Residual Activity:** Provides season-long weed control. Length of residual activity depends upon soil and moisture factors, application rate and timing. Heavy rainfall following an incorporated treatment may reduce weed control. **Unique Characteristics:** No recropping restrictions in the fall or spring application in corn or soybeans. Application flexibility; there are many tank-mix and sequential treatment options for broad-spectrum weed control in corn and soybeans in all tillage systems (zero tillage to conventional tillage). Mixes well with bulk liquid and dry fertilizers.

## DIQUAT

**Trade Name:** REGLONE DESICCANT. **Chemical Family:** Bipyridylium. **Crop and/or Non-Crop Registrations:** Desiccation of canola (rapeseed), flax, dry beans, dry peas, mustard, sunflowers, soybeans, adzuki beans, legume seed crops. Vine killing of potatoes. Control of corn spurry in oats. Stale seedbed and inter-row weeding. **Sensitive Weeds:** Any foliage contacted by diquat will be killed. **Uptake and Translocation:** Rapidly absorbed by foliage. Limited translocation. **Basis of Selectivity:** None. **Application Methods:** Postemergence. **Residual Activity:** Essentially none due to adsorption of chemical to soil particles. **Unique Characteristics:** Must be used with clean (non-turbid) water as the soil particles in muddy water drastically reduce the effectiveness of diquat. Apply in weather conditions that will not promote drift. For aerial application, suggested conditions for good application are moderate temperatures (less than 25°C), humidity (greater than 40%) and wind (3.6–10 km/h). Do not apply in dead calm conditions or when temperature inversion is likely (e.g., morning or evening when warm air is rising from crop). To avoid spray drift, use flat fan or hollow cone nozzles and a pressure of 140–210 kPa. For aerial application, point the nozzles back 130°–180°. For further information on aerial application, refer to the product label.

## DIQUAT (AQUATIC)

**Trade Name:** REWARD. **Chemical Family:** Bipyridylium. **Crop and/or Non-Crop Registrations:** Aquatic weed control in still or flowing water in ponds, ditches, lakes and canals. **Sensitive Weeds:** Coontail, Canada water weed, pondweeds, milfoil and duckweed. **Uptake and Translocation:** Contact desiccant with limited translocation. **Basis of Selectivity:** None. **Application Methods:** Postemergence. Apply when weeds are visible and are actively growing. It can be applied: with a boat bailer device that injects the chemical below the water surface; sprayed over the water surface; or poured directly from a container onto the surface. **Residual Activity:** Quickly inactivated by adsorption to soil particles. **Unique Characteristics:** Must be used with and applied on non-turbid water, as the soil particles in muddy water drastically reduce the effectiveness of the material. Apply at dusk. Do not use treated water for swimming or consumption by humans or animals for at least 24 hours. Do not use water for irrigation for 5 days after treatment. To avoid fish kills caused by oxygen depletion, treat only one-quarter to one-third of the area at a time. Avoid application or drift onto crops, lawns, grazing areas, ornamental plants and other desirable plants.

## DIURON

**Trade Name:** KARMEX. **Chemical Family:** Substituted urea. **Crop and/or Non-Crop Registrations:** Grapes, asparagus, gladioli, industrial sites, right-of-ways. **Sensitive Weeds:** Annual and perennial grasses, pigweed, ragweed, wild carrot and dandelion. Perennial weed control at higher rates in non-crop areas. **Uptake and Translocation:** Most readily absorbed by roots, less so by foliage. Translocated upward in the xylem. **Basis of Selectivity:** Used only in deep-rooted crops that are well established. **Application Methods:** Applied to crops as a preemergence or directed early postemergence spray, preferably before weed growth becomes dense. Better control of emerged weeds is obtained by the addition of a suitable surfactant. In non-crop areas, diuron may be sprayed any time except when the ground is frozen. **Residual Activity:** At lower rates used in crops, residues last about a year and thus applications may be repeated annually. At higher non-crop rates, persistence may be more than 1 year. **Unique Characteristics:** Should not be used where it is likely to leach or wash into contact with the roots of desirable trees or shrubs.

## ENDOTHALL

**Trade Name:** HERBICIDE 273. **Chemical Family:** dicarboxylic acid **Crop and/or Non-Crop Registrations:** Sugarbeets. **Sensitive Weeds:** Lady's-thumb, wild buckwheat, redroot pigweed, green foxtail and barnyard grass. **Uptake and Registration:** Absorbed through the roots and shoots of actively growing weeds. **Basis of Selectivity:** Not established. **Application Method**: 1) Preemergence broadcast spray onto seedbed during or just after planting. May also mix with sand and apply as a banded treatment. 2) Postemergence — apply as a broadcast or banded treatment only after the weeds have emerged. For best results, the sugarbeets should be in the 4- to 6-leaf stage and the average temperature should be above 15°C. Do not apply later than 40 days after emergence. **Residual Activity:** Very short, up to 7 days. **Unique Characteristics:** High moisture after application is essential for the best weed control. Works very slowly. Only tankmix with betamix or betanex to expand weed control to include smartweed, knotweed, lamb's-quarters, ragweed, shepherd's-purse and nightshade.

## EPTC

**Trade Name:** EPTAM. **Chemical Family:** Thiocarbamate. **Crop and/or Non-Crop Registrations:** Alfalfa, bird's-foot trefoil, snap or dry beans (including kidney), flax, potatoes, sunflowers and annual flowers. **Sensitive Weeds:** Annual grasses such as crab grass, barnyard grass, fall panicum, wild oats, green foxtail and yellow foxtail; yellow nut sedge; some annual broadleaf weeds such as corn spurry, lamb's-quarters, nightshade, pigweed and chickweed if conditions are favourable for germination and growth. **Uptake and Translocation:** Uptake by underground plant parts (roots, hypocotyl and seed). Upward translocation to the growing tip. **Basis of Selectivity:** Metabolized by tolerant species at the seed germination stage through enzymatic breakdown of the chemical. Seed food reserves also permit seedling to outgrow chemical effect. **Application Methods:** Preplant incorporated or postplant incorporated. May be applied using water or liquid fertilizers as the carrier. Dry fertilizers may also be used as a carrier when impregnated by licensed fertilizer dealers. To prevent chemical loss and reduced weed control, EPTC should be uniformly incorporated in the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator with sweep teeth or vibrating shank S-tine cultivator) to work the soil approximately 10 cm deep, followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are done in separate operations, application should be a dry soil surface. **Residual Activity:** Applied in the spring preplant, EPTC provides season-long weed control with no soil residues the following year to prevent crop rotation. **Unique Characteristics:** EPTC does not need rainfall to activate and will not leach significantly under heavy rainfall. Under unfavourable germination conditions, leaf crinkling or leaf sealing may be observed on certain crops but usually without adverse effects on yield. May be tank-mixed with metribuzin for additional broadleaf weed control in potatoes. May be tank-mixed with ethalfluralin or trifluralin for additional broadleaf weed control in beans (white, snap and kidney). See label for other tank-mix combinations and information on less conventional methods of application.

## EPTC/R25788 (EPTC+)

**Trade Name:** ERADICANE. **Chemical Family:** Thiocarbamate. **Crop and/or Non-Crop Registrations:** Corn (ensilage, field and sweet). **Sensitive Weeds:** Annual grasses such as wild oats, crab grass, barnyard grass, foxtails, fall panicum; suppression of wild proso millet; yellow nut sedge, horsetail and some annual broadleaf weeds when conditions are favourable for germination and growth. **Uptake and Translocation:** Uptake by underground plant parts (roots, hypocotyl and seed) then upward translocation to the growing tip. **Basis of Selectivity:** Metabolized by tolerant species at the seed germination stage through breakdown of the chemical. R25788 enhances the enzymatic breakdown of the chemical in tolerant species. Also, seed food reserves permit corn seedlings to outgrow chemical effect. **Application Methods:** EPTC/R25788 may be applied using water or liquid fertilizers as the carrier. Dry fertilizers may also be used as a carrier when impregnated by licenced fertilizer dealers. To prevent chemical loss and reduced weed control, EPTC/R25788 should be uniformly incorporated into the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator with sweep teeth or vibrating shank S-tine cultivator) to work the soil approximately 10 cm deep, followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are done in separate operations, application should be to a dry soil surface and incorporation should be made within 4 hours of application. Preplant incorporated EPTC+ may be used in tank-mix combination with 1) atrazine for additional broadleaf weed control or 2) metolachlor using reduced rates of both herbicides for more consistent control of many annual grasses. **Residual Activity:** Provides season-long weed control with no soil residues the following year to prevent crop rotation. In tank-mix combinations with atrazine, there may be atrazine residues when the highest atrazine rate is used. **Unique Characteristics:** EPTC/R25788 does not need rainfall to be activated and will not leach significantly under heavy rainfall.

## ETHOFUMESATE

**Trade Name:** NORTRON. **Crop and/or Non-Crop Registrations:** Sugarbeets. **Sensitive Weeds:** Chickweed, lamb's-quarters, kochia, redroot pigweed, Russian thistle, wild buckwheat, barnyard grass, large crab grass, foxtails and downy brome. **Uptake and Translocation:** Readily absorbed by emerging shoots (grass coleoptile and broadleaf hypocotyl) and roots, and translocated readily to the foliage. Postemergence applications of ethofumesate are poorly absorbed by maturing leaves with a well-developed cuticle. **Basis of Selectivity:** Tolerant species conjugate the herbicide, rendering it inactive. **Application Methods:** Preplant incorporated, preemergence. **Residual Activity:** Half-life of less than 5 to more than 14 weeks depending on soil temperature and moisture conditions. Half-life increases in cooler, drier soils.

## FENOXAPROP-P-ETHYL

**Trade Name:** EXCEL SUPER, ACCLAIM SUPER. **Chemical Family:** Aryloxyphenoxypropionate. **Crop and/or Non-Crop Registrations:** EXCEL SUPER — Asparagus, broccoli, cabbages, cauliflower, carrots, dry common beans (kidney, pinto and white only), onions (dry bulb only), peas (field and processing), potatoes, canola (rapeseed), triazine-tolerant canola, soybeans, tomatoes. ACCLAIM SUPER — Lawns and turf. **Sensitive Weeds:** Barnyard grass, green and yellow foxtail, crab grass, witch grass, wild proso millet, fall panicum, volunteer corn. **Uptake and Translocation:** Uptake primarily through the leaves. Does not translocate significantly. **Basis of Selectivity:** Differential metabolism by tolerant vs. sensitive species. **Application Methods:** Non-residual postemergence for the control of annual grasses (EXCEL SUPER — 1- to 6-leaf stage; ACCLAIM SUPER — 1- to 4-leaf stage plus 3 tillers). For best results, apply when weeds are young and actively growing. EXCEL SUPER — Do not apply if rainfall is expected within 1 hour of application. ACCLAIM SUPER — Do not apply if rainfall is expected within 3 hours of application. **Residual Activity:** Essentially none. **Unique Characteristics:** EXCEL can be tank-mixed with BASAGRAN FORTE and/or PINACLE for broad-spectrum annual weed control in soybeans and dry beans only. If annual grasses are in the correct stage for application before broadleaf weeds have emerged, do not delay EXCEL SUPER application.

## FLUAZIFOP-P-BUTYL

**Trade Names:** FUSILADE II, VENTURE. **Chemical Family:** Aryloxyphenoxypropionate. **Crop and/or Non-Crop Registrations:** Flax, canola, soybeans, sugarbeets, sunflowers, tobacco, forage legumes (alfalfa, red clover and bird's-foot trefoil), cabbages, broccoli, Brussels sprouts, cauliflower, cucumbers, onions, potatoes, rutabagas, tomatoes, highbush blueberries, raspberries, strawberries, non-grassy ornamental plants, poplars, shrubs, trees, apples, apricots, cherries, cranberries, peaches, pears and plums, forest and ornamental nurseries. **Sensitive Weeds:** Annual grass species, volunteer corn, wheat, barley and quack grass. **Uptake and Translocation:** Absorbed primarily by leaves. Translocated to roots and rhizomes. **Basis of Selectivity:** Metabolism by tolerant species. **Application Methods:** Postemergence. Apply when grasses are actively growing, and annual grasses are in the 2- to 5-leaf stage and quack grass is in the 3- to 5-leaf stage. **Residual Activity:** Essentially none. **Unique Characteristics:** Preplant tillage to break up rhizomes will improve control of quack grass. Except as noted on the label, broadleaf herbicides should be applied separately at least 3 days after fluazifop-p-butyl. Do not cultivate for 5 days after applying fluazifop-p-butyl. When plants are stressed (lack of moisture, excessive humidity, low temperature and/or very low relative humidity), fluazifop-p-butyl is less effective. Regrowth by tillering may occur if application is made under any of the above conditions. Since there is no residual activity, a new flush of weeds may emerge after the first flush has been controlled.

## FOMESAFEN

**Trade Name:** REFLEX. **Chemical Family:** Diphenyl ether. **Crop Registrations**: Soybeans, beans (white, kidney and snap). **Sensitive Weeds:** Redroot pigweed, common ragweed, wild mustard, lady's-thumb, black nightshade, cocklebur; suppression of velvetleaf, lamb's-quarters. **Uptake and Translocation:** Taken up through foliage. Not readily translocated. **Mode of Action:** Cell-membrane disrupter. **Method of Selectivity**: Beans metabolize fomesafen. Some initial bronzing of crop leaves may occur, but plants normally outgrow this condition without any effect on maturity or yield. **Application Method**: Early postemergence to weeds and crop. Apply when beans are 1–2 trifoliate and weeds are at the 2- to 4-leaf stage. Good coverage is essential for optimum weed control. Apply in 200–350 L of water/ha at a pressure between 245–420 kPa. Always add an adjuvant such as AGRAL 90 (0.25% v/v) or TURBOCHARGE (0.5% v/v). PINNACLE or VENTURE may be tank-mixed for additional weed control. **Residual Activity:** Persistence depends on weather and soil conditions (more persistent under dry conditions). Rotation to field corn, dry beans or soybeans the following year. Winter wheat may be planted 90 days after treatment. All other crops require a field bioassay. **Unique Characteristics:** Do not apply REFLEX to any field more than once every 2 years.

## FUMIGANTS

See METAM SODIUM (page 175) and METHYL BROMIDE/CHLOROPICRIN (page 176).

## GLUFOSINATE AMMONIUM

**Trade Name:** IGNITE, LIBERTY 200SN. **Chemical Family:** Unique. **Crop and/or Non-Crop Registrations:** IGNITE — Desiccation of dry beans and potatoes; directed applications in apples, grapes, peaches, pears and plums; stale seedbed techniques in asparagus, carrots, lettuce and onions; ground crack application in potatoes. LIBERTY 200SN — Corn hybrids and canola varieties specially developed to be tolerant to Liberty 200SN herbicide. Glufosinate-ammonium tolerant inbred lines grown for seed corn production. **Sensitive Weeds:** Non-selective —affects all actively growing green plants; regrowth of perennial species may occur. **Uptake and Translocation:** Absorbed through foliage; minimal translocation — dependent on application rate and species treated. **Basis of Selectivity:** IGNITE — All green plant tissue is sensitive; safe on mature (non-green) bark of woody plants. LIBERTY 200SN — All green plant tissue is sensitive except for field corn, seed corn and canola plants that have been specially developed to be tolerant. **Application Methods:** IGNITE — Postemergence; broadcast or directed spray to avoid contact with leaves or green bark of desirable plants; thorough coverage of the plant tissue to be controlled is essential. LIBERTY 200SN — Postemergence. Can be broadcast in corn at the 1–8 leaf stage, apply with drop nozzles to later corn growth stages; cotyledon to early bolting stage in canola. **Residual Activity:** None; there are no cropping or rotational restrictions after application. **Unique Characteristics:** Speed of action is influenced by environmental factors; at cool temperatures, poor moisture and low humidity, speed of action may be reduced. Heavy dew at time of application may reduce control of certain weed species.

## GLYPHOSATE TMS

**Trade Name:** TOUCHDOWN 480. See GLYPHOSATE, below.

## GLYPHOSATE

**Trade Names:** CREDIT, CLEAR-IT 1, CLEAR-IT 2, CLEAR-IT 3, EXPEDITE GRASS & WEED, E-Z-JECT, GLYFOS, LAREDO, MAVERICK, RENEGADE, ROUNDUP, ROUNDUP DRY, ROUNDUP L & G, ROUNDUP TRANSORB, TOUCHDOWN 480, TOUCHDOWN 600, VANTAGE, VANTAGE PLUS, VISION, WRANGLER. **Chemical Family:** Amino acid. **Crop and/or Non-Crop Registrations:** CREDIT, GLYFOS, LAREDO, RENEGADE, ROUNDUP, ROUNDUP TRANSORB, VANTAGE, VANTAGE PLUS, WRANGLER — Preplant or post-harvest with no cropping restrictions. Preharvest in wheat, barley, soybeans, canola, flax, lentils, field peas and forages. TOUCHDOWN 480 for preharvest use in canola, barley, field beans, field peas, soybeans and wheat. ROUNDUP, ROUNDUP TRANSORB, VANTAGE, and VANTAGE PLUS for in-crop uses in Roundup Ready crops. Directed applications in ginseng, cherries, grapes, apples, pears, plums and peaches, strawberries as wiper or spot treatment. Non-crop registrations: EXPEDITE GRASS & WEED, ROUNDUP — brush control; turf renovation; chemical mowing; directed application in woody nursery stock, roadsides and shelterbelts. ROUNDUP — asparagus. E-Z-JECT — selective woody brush and tree control. VISION — silvicultural site preparation, conifer release, forest tree plantings, forest tree nurseries. **Sensitive Weeds:** Annual grasses; perennial weeds (quack grass, Canada thistle, sow-thistle, field bindweed, milkweed, cattails, nut sedge, poison-ivy, etc.); brush (birch, alder, poplar, raspberry, willow and maple. **Uptake and Translocation:** Absorbed through foliage and translocated throughout the plant. **Basis of Selectivity:** Non-selective for agricultural crops. Conifers are tolerant at some stages, but the basis has not been established. **Application Methods:** Postemergence, usually at the bud to bloom stage of growth for most perennial weeds. Canada thistle should be at least in early flower bud, milkweed at flower bud, and bindweed at full flower. Quack grass can be treated in the spring or fall when it is actively growing with at least 3–4 new leaves on each emerged shoot; in the fall, remove crop refuse but do not till prior to application; fall or spring tillage prior to spring application may reduce control; wait at least 3–5 days after application before working the area; for maximum control, it is advisable to till before the quack grass turns completely brown. Glyphosate can be applied with boom equipment, knapsack sprayers and high-volume equipment for agricultural and non-crop uses. Backpack mist blowers may be used for silvicultural site preparation and roadside brush control only. Aerial applications may be used for silvicultural site preparation and conifer release only. Can also be applied with selective equipment for non-crop areas, tree plantings, grapes and orchards (See the sections *Special Methods of Weed Control*, on page 194, and *Wick Wiper and Roller Application*, on page 198). Regardless of method of application, do not allow herbicide solution to contact green foliage or green bark of crop or other desirable plants; remove all suckers from the trunks of desirable trees before spraying. **Residual Activity:** None: crops can be planted or seeded directly into treated areas following application. Other herbicides are required to control weeds emerging after the application. **Unique Characteristics:** Rainfall within 6 hours after application or heavy frost within 24 hours may reduce control. ROUNDUP TRANSORB is rainfast as soon as 4 hours after application.

## GLYPHOSATE/GLUFOSINATE AMMONIUM

**Trade Name**: ROUNDUP FASTFORWARD PRESEED, ROUNDUP FASTFORWARD PREHARVEST. **Chemical Family:** Amino acid/Unique. **Crop and/or Non-Crop Registrations:** ROUNDUP FASTFORWARD PRESEED — Preplant treatments with no cropping restrictions. ROUNDUP FASTFORWARD PREHARVEST — Preharvest treatments in wheat, drybeans, canola, flax, field peas and lentils. **Sensitive Weeds**: Annual grass and broadleaf weeds and many perennials such as quack grass and Canada thistle. **Translocation:** Absorbed through foliage and translocated throughout the plant. **Basis of Selectivity:** Nonselective for agricultural crops. **Application Methods**: Postemergence to actively growing weeds using boom equipment (see GLYPHOSATE note, above, for more information). **Residual Activity:** None: Crops can be planted directly into the treated areas following application. **Unique Characteristics:** Glyphosate/glufosinate ammonium provides quicker burn-down of green vegetation than glyphosate alone. Rainfall within 2 hours after application or a heavy frost within 24 hours may reduce control.

## HERBICIDAL OIL

See MINERAL OIL (HERBICIDAL) (page 176).

## IMAZETHAPYR

**Trade Name:** CONQUEST B (Available only in CONQUEST co-pack), PURSUIT. **Chemical Family:** Imidazolinone. **Crop and/or Non-Crop Registrations:** Soybeans, white beans, kidney beans, snapbeans, imidazolinone-tolerant corn (IR), processing peas and alfalfa for seed production. **Sensitive Weeds:** Soil applications — green foxtail, yellow foxtail, old witch grass, barnyard grass, lamb's-quarters, redroot pigweed, smartweed, lady's-thumb, wild mustard, velvetleaf, common ragweed and reduced competition from eastern black nightshade and proso millet. Postemergence application — green foxtail, yellow foxtail, witch grass, barnyard grass, redroot pigweed, velvetleaf, wild mustard, cocklebur, eastern black nightshade, ragweed and reduced competition from proso millet, large crab grass, lamb's-quarters, wild buckwheat and yellow nut sedge. Late postemergence application — green and yellow foxtail (up to 4-leaf stage), barnyard grass (up to 6-leaf stage), redroot pigweed (up to 12-leaf stage) and velvetleaf (up to 8-leaf stage). **Uptake and Translocation:** Absorbed by both roots and foliage. Translocation in both xylem and phloem. **Basis of Selectivity:** Metabolism by tolerant species. **Application Methods:** Early preplant (up to 30 days before planting), preplant incorporated, preemergence and postemergence up to the 2-leaf stage of weeds, and late postemergence on specific weeds (see *Sensitive Weeds*, above). **Residual Activity:** Persistence depends on weather and soil conditions (more persistent under dry conditions). Rotational cropping restricted to soybeans, white beans, kidney beans, processing peas, corn, spring barley, spring wheat and winter wheat. Do not plant other crops the year following application as injury may result. **Unique Characteristics:** Can be applied up to 30 days prior to planting. Registered for use in reduced and no-till situations. tank-mixing is recommended for heavy infestations of ragweed or barnyard grass. Postemergence application requires the addition of AGRAL 90, AGSURF or ENHANCE surfactant and liquid fertilizer solution. Temporary soybean discolouration and/or shortening may occur with postemergence applications. A period of 100 days is required between application and planting winter wheat.

## LINURON

**Trade Name:** AFOLAN F, LINURON 480, LOROX DF, LOROX L. **Chemical Family:** Substituted urea. **Crop and/or Non-Crop Registrations:** Corn, soybeans, carrots, celery, dill, parsnips, potatoes, asparagus, wheat, oats, barley, gladioli, fruit trees. **Sensitive Weeds:** Annual weeds such as barnyard grass, common chickweed, corn spurry, crab grass, velvetleaf, fall panicum, foxtail, goosefoot, goose grass, groundsel, knotweed, lamb's-quarters, redroot pigweed, purslane, common ragweed, shepherd's-purse, smartweed, stinkweed, wild buckwheat, witch grass, wormseed mustard, triazine-resistant weeds; seedlings only of dandelion, plantain and sow-thistle. **Uptake and Translocation:** Readily absorbed through roots, less so through foliage; translocation primarily upwards in xylem. **Basis of Selectivity:** Differential metabolism often coupled with differential uptake and translocation. **Application Methods:** Preemergence, postemergence, directed postemergence, pre- plus postemergence. **Residual Activity:** Does not pose a problem for subsequent crops since phytotoxic residues from applications at agricultural rates disappear within 4 months. **Unique Characteristics:** Do not use on sandy or coarse-textured soils having less than 2% organic matter. If unusually heavy rains follow application, severe injury may occur to corn, soybeans, carrots and potatoes.

## MALEIC HYDRAZIDE

**Trade Name:** ROYAL MH 60 SG. **Chemical Family:** Unique. **Crop and/or Non-Crop Registrations:** Growth control in lawns, turf, trees and shrubs. Sprout control in stored onions and potatoes. **Sensitive Weeds:** Controls the growth of wild onion, garlic and biennial-type weeds such as dandelion and plantain when applied in the fall. **Uptake and Translocation:** Absorbed through foliage. Translocated to active growing points in plant. Translocated more effectively downwards. **Basis of Selectivity:** Not established. **Application Methods:** Postemergence. Use as a foliar spray. Dosage and stage of plant development are critical factors. To reduce or eliminate mowing, apply in the spring or fall to green non-dormant grass; can be mixed with 2,4-D for spring applications. For tree and shrub growth control, apply to the portion of the plant on which growth is to be inhibited; growth control is best when applied to vigorous new growth; spray leaves and bark to point of run-off. **Residual Activity:** None. **Unique Characteristics:** Do not apply on or near crops being grown for seed. Rain within 24 hours after application will reduce effectiveness. Since temporary discolouration of grass may result, this chemical is recommended for use in areas where mowing grass is difficult and where lawn-like appearance is not necessary.

## MCPB/MCPA

**Trade Name:** CLOVITOX PLUS, TROPOTOX PLUS. **Chemical Family:** Phenoxy/phenoxy. **Crop and/or Non-Crop Registrations:** Seedling white, ladino, alsike or red clovers direct seeded or underseeded in wheat, oats, barley, rye, pastures, field corn, peas, grapes. **Sensitive Weeds:** Small emerged mustards, stinkweed, ragweed, lamb's-quarters, redroot pigweed, shepherd's-purse, volunteer rapeseed, wild radish, hemp-nettle, annual sow-thistle; top-growth control of bull thistle, Canada thistle, curled dock, plantain, perennial sow-thistle, field bindweed, horsetail, buttercup. **Uptake and Translocation:** Absorbed through the foliage and readily translocated, especially to the growing points. **Basis of Selectivity:** MCPB is not directly toxic to plants. Susceptible weeds convert MCPB to MCPA. **Application Methods:** Postemergence. In cereals, clovers and peas, apply as an overall spray. In corn, apply with drop pipes after the corn reaches 45 cm before the beginning of tasselling. Apply to pastures after grazing or cutting.

## METAM SODIUM

**Trade Name:** VAPAM **Chemical Family:** Thiocarbamate. **Crop and/or Non-Crop Registrations:** Field and greenhouse seedbeds. Field-replant sites of fruits, vegetables, tobacco, ornamentals and forest-tree stock. **Sensitive Weeds:** Most scarified weed seeds and freshly vegetative parts including rhizomes and germinating seedlings. **Basis of Selectivity:** Most plant parts are sensitive. Crops are not planted until all fumigant has dissipated from the soil. With moisture, methyl isothiocyanate gas is released, which kills most scarified seeds and fleshy vegetative parts including rhizomes and germinating seedlings. **Application Methods:** Apply uniformly using injectors, water or other incorporation tools to carry the product to the desired soil depth. May be applied via the irrigation system. No gas-proof cover is required unless the soil is very porous, however, a sprinkler application of water should be used to provide a surface "water seal." **Residual Activity:** 10 to 40 days depending on soil temperature and the amount of organic matter present in the soil. Persistence is greatest at low temperatures and high levels of organic matter. Planting may take place 12 to 16 days after the treatment and following a lettuce-seedling bioassay that indicates no injury. **Unique Characteristics:** Also controls nematodes, soil fungi and soil insects. All traces of toxic gases must be dissipated from the treated soil before planting, or plant injury may occur.

## METHYL BROMIDE/CHLOROPICRIN

**Trade Name:** TERR-O-GAS 67. **Chemical Family:** Organohalogen. **Crop and/or Non-Crop Registrations:** Greenhouse and tobacco seedbeds. Methyl bromide is very poisonous to humans and livestock; only an experienced operator should attempt its use. **Sensitive Weeds:** Gas is toxic to germinating seedlings. **Application Methods:** Formulated as a liquid under pressure, that, when released from the container, forms a gas. Soil must be sealed with a plastic sheet since the gas is highly volatile. Refer to label for detailed directions. **Unique Characteristics:** Methyl bromide gas is highly volatile and highly poisonous to humans and livestock. It may be absorbed by inhalation, ingestion and skin contact. A permit must be obtained from the Ontario Ministry of the Environment and Energy each time it is used. Also controls soil insects, nematodes and fungal diseases.

## METOBROMURON

**Trade Name:** PATORAN FL. **Chemical Family:** Substituted urea. **Crop and/or Non-Crop Registrations:** Soybeans, dry common beans (kidney, white, yellow-eye), lima beans, snap common beans, adzuki beans, potatoes. **Sensitive Weeds:** Annual broadleaf weeds (including triazine-tolerant biotypes) such as pigweed, lamb's-quarters, green smartweed, ragweed, lady's-thumb, shepherd's-purse, annual nightshades, cudweed, corn spurry, groundsel, purslane, chickweed, mustards and stinkweed. Some activity on annual grasses such as barnyard grass, crab grass, green foxtail, witch grass, annual bluegrass and stink grass. The annual grasses are the first to escape treatment. **Uptake and Translocation:** Absorbed through the roots. Translocated in the transpiration stream to the leaves where it accumulates at the margins. **Basis of Selectivity:** Achieved through differential interception of the herbicide. Metobromuron must be placed on the soil surface and move into the zone of germinating weed seeds but not come in contact with the roots of the germinating crop plants. **Application Methods:** Preemergence. For beans, apply before the beans and weeds emerge; beans should be planted 4–5 cm deep; shallow-planted crops may be injured; do not use on soils with less than 2% organic matter; optimum organic levels are 2%–5%. For potatoes, metobromuron should be applied at ground crack after the first hilling, provided the soil completely covers the emerged potato tips. **Residual Activity:** Relatively short (6–8 weeks). **Unique Characteristics:** Moisture is required for distribution into the top layer of soil where weed seeds are germinating. Soil residues do not carryover to affect subsequent crop rotations.

## METOLACHLOR

See S-METOLACHLOR (page 181).

## METOLACHLOR/ATRAZINE

See S-METOLACHLOR/ATRAZINE (page 181).

## METRIBUZIN

**Trade Names:** CONQUEST A (available only in CONQUEST co-pack), EVICT SOLUPAK, LEXONE DF, SENCOR 500 F, SENCOR 75 DF, SENCOR SOLUPAK. **Chemical Family:** S-triazine. **Crop and/or Non-Crop Registrations:** Established asparagus, faba beans, potatoes, soybeans, transplant tomatoes, apples, apricots, peaches, cherries, corn and triazine-tolerant canola with trifluralin or with terbacil or with metolachlor on apples, apricots, cherries, plums, peaches and pears. **Sensitive Weeds:** Lamb's-quarters, wild mustard, redroot pigweed, common ragweed, shepherd's-purse, lady's-thumb, velvetleaf, jimsonweed, prostrate pigweed, Russian thistle, yellow wood-sorrel, prickly mallow, chickweed, cocklebur, carpetweed, dandelion seedlings, barnyard grass, crab grass, foxtail, fall panicum, witch grass, Johnson grass seedlings and cheat grass. **Uptake and Translocation:** Some uptake through the foliage but the major route is via the roots. Translocation upwards in the xylem. **Basis of Selectivity:** Degradation by tolerant species. **Application Methods:** Preplant incorporated (potatoes, soybeans, apples, apricots, peaches, cherries, corn, tomatoes and triazine-tolerant canola); preemergence (asparagus, potatoes, soybeans and triazine-tolerant canola); postemergence (potatoes, tomatoes, corn and triazine-tolerant canola). **Residual Activity:** Varies with the climate. At normal-use rates, the half-life is 1–2 months. **Unique Characteristics:** Heavy rainfall following application may cause crop damage. Some varieties of potato, soybean and tomato are less tolerant than others. Triazine-resistant weeds are not controlled. Do not use on muck soils.

## MINERAL OIL (HERBICIDAL)

**Trade Name:** AGRICULTURAL WEED KILLER NO. 1. **Chemical Family:** Aliphatic and aromatic hydrocarbons. **Crop and/or Non-Crop Registrations:** Carrots, celery, dill, parsley, parsnips. **Sensitive Weeds:** Annual weeds with the exception of ragweed, wormweed and wild carrot. **Uptake and Translocation:** Absorbed by foliage. Little or no translocation. **Basis of Selectivity:** Low-interception species such as the *Umbelliferae* family are tolerant. **Application Methods:** Postemergence; broadcast or banded. For carrots, dill, parsley and parsnips, apply as soon as true leaves develop and before roots are thicker than a pencil. For celery, apply as soon as true leaves develop. Weeds should be less than 10 cm tall. Best results will be obtained if spray is applied on cool sunny mornings; do not apply when excessively hot. **Residual Activity:** None. **Unique Characteristics:** Do not apply within 30 days of harvest as late application may flavour the harvested crop.

## MONOLINURON

**Trade Name:** AFESIN. **Chemical Family:** Substituted urea. **Crop and/or Non-Crop Registrations:** Soybeans, white beans, yellow eye beans, kidney beans, lima beans, snap beans, potatoes. **Sensitive Weeds:** Particularly effective on most annual broadleaf weeds including triazine-resistant biotypes. Some activity on annual grasses but these will be the first to escape. Cultivation may be required. **Uptake and Translocation:** Uptake is primarily through the roots of germinating weed seedlings, although leaf uptake is possible. Translocated upwards in the xylem to the shoots. **Basis of Selectivity:** Monolinuron is placed on the soil surface and moves down into the zone of germinating weed seeds but not deep enough to come in contact with the roots of germinating crop plants. **Application Methods:** Preemergence. For beans, apply before the beans and weeds emerge; beans should be planted 4–5 cm deep; shallow-planted crops may be injured; do not use on soils with less than 3% organic matter. On potatoes, apply preemergence or when plants are covered by hilling. **Residual Activity:** Relatively short, 4–6 weeks. **Unique Characteristics:** Moisture is required for distribution into the top layer of soil where weed seeds are germinating.

## NAPROPAMIDE

**Trade Names:** DEVRINOL 50 DF, DEVRINOL 50W, DEVRINOL 10G. **Chemical Family:** Amide. **Crop and/or Non-Crop Registrations:** Asparagus, cole crops (cabbages, broccoli, cauliflower, Chinese broccoli, Chinese mustard greens, Chinese nappa cabbage, Chinese radish), garlic, kohlrabi. peppers, pumpkins, squash, fuzzy squash, rutabagas, tomatoes, tobacco, raspberries, blackberries, cultivated lowbush blueberries, established highbush blueberries, boysenberries, cranberries, loganberries, newly planted or established strawberries, apples, grapes, peaches and pears, newly transplanted or established ornamentals, woody nursery stock, forest tree stock and container-grown ornamentals (see label for species). With simazine or with terbacil on new plantings of apples, apricots, cherries, plums, peaches and pears. **Sensitive Weeds:** Many annual weeds, including crab grass, barnyard grass, annual bluegrass, foxtails, sandbur, wild oats, goose grass, chickweed, groundsel, redroot pigweed, lamb's-quarters, purslane, prostrate knotweed, pineappleweed and prickly lettuce. **Uptake and Translocation:** Absorbed through the roots of germinating weeds. Translocated upward through seedling. **Basis of Selectivity:** Metabolized by tolerant species. Root growth of germinating seedlings is inhibited. Established plants are not affected due to placement selectivity. **Application Methods:** May be applied preplant incorporated using water as the carrier. Incorporation should be uniform, and to a chemical depth of 2.5–5 cm, using irrigation or proper incorporation equipment (e.g., tandem discs or field cultivator with sweep teeth) followed by a levelling device. On established crops, apply to a weed-free soil surface and irrigate in if no rainfall occurs within 7 days after application in spring or fall, or within 2 days after application in summer; irrigate with sufficient water to wet the soil to a depth of 5–10 cm (approximately 7 mm of rain). For post-plant application in tobacco, apply in 25 cm band over the row. Cross-disc or cross-plough after harvest to dilute soil residue before planting cover crop. **Residual Activity:** Provides season-long weed control if properly incorporated. Deep ploughing will minimize any carryover effect. **Unique Characteristics:** Will not control germinated weeds. Resists leaching. To avoid injury to crops not registered for use with napropamide, do not plant until 12 months after the last napropamide application.

## NAPTALAM

**Trade Name:** ALANAP. **Chemical Family:** Amide. **Crop and/or Non-Crop Registrations:** Cucumbers, melons, squash and pumpkins. **Sensitive Weeds:** Seedlings of bindweed, chickweed, cocklebur, lamb's-quarters, pigweed, purslane, ragweed, velvetleaf, crab grass and foxtail. **Uptake and Translocation:** Inhibits seed germination and may be absorbed through the root system after germination. **Application Methods:** Preemergence. Soil clods should be thoroughly broken up and pulverized to give a smooth surface before spray applicaton. Apply up to 48 hours after planting. Following applications, the soil should not be disturbed unless later weed growth makes cultivation necessary. A second application may be applied to cucumbers and melons about 1 month after the first spray, when the crop has emerged but before the weeds are up. Use lower rates on light soil, higher rates on heavy soil. **Residual Activity:** Completely decomposes in 6–8 weeks. **Unique Characteristics:** Do not apply during very wet, cold weather as stunting of the crop may result. Avoid spray drift to areas planted to sensitive crops such as beets, tomatoes and spinach.

## NICOSULFURON

**Trade Name:** ACCENT. **Chemical Family:** Sulfonylurea. **Crop and/or Non-Crop Registrations:** Field corn, certain varieties only of sweet corn and seed corn (contact seed source for details on specific inbreds). **Sensitive Weeds:** Quack grass, proso millet, green and yellow foxtail, fall panicum, barnyard grass, old witch grass. **Uptake and Translocation:** Following foliar absorption, nicosulfuron is rapidly absorbed through the leaves and translocated in both xylem and phloem. **Basis of Selectivity:** Inhibition of acetolactate synthase (ALS) enzyme in susceptible plants leads to a rapid cessation of cell division and regrowth. Tolerant species rapidly convert nicosulfuron to non-phytotoxic metabolites. **Application Method**: Postemergent within the 1- to 8-leaf stage of corn. **Residual Activity:** No soil residual activity. **Unique Characteristics:** Emerged grasses will be controlled by nicosulfuron but subsequent germinating grasses will not be controlled. A non-ionic surfactant must be added at 0.2% v/v. Typical symptoms of plant death (chlorosis, necrosis) occur 5–10 days after application, depending on growing conditions. Do not apply to corn that has been treated with an organophosphorous soil insecticide (i.e., COUNTER, LORSBAN, THIMET, CYGARD or DI-SYSTON).

## OXYFLUORFEN

**Trade Name:** GOAL. **Chemical Family:** Diphenyl ether. **Crop and/or Non-Crop Registrations:** Onions. **Sensitive Weeds:** Purslane, pigweed, annual nightshades, wild buckwheat, lamb's-quarters. **Uptake and Translocation:** Primarily foliar absorption but some root absorption. Very little movement within the plant following foliar or root absorption. **Application Methods:** Postemergence. Best control is obtained when weeds are in the 2- to 4-leaf stage and actively growing. The first application can be made when onions have 2 fully developed true leaves. Repeat applications may be necessary to control late-germinating weeds. Use at least 500 L of water/ha. **Residual Activity:** Limited preemergence activity. **Unique Characteristics:** Use on dry bulb onions. Do not use when crop or weeds are under stress. Do not apply within 56 days prior to harvest.

## PARAQUAT

**Trade Name:** GRAMOXONE. **Chemical Family:** Bipyridylium. **Crop and/or Non-Crop Registrations:** Apples, apricots, cherries, currants, gooseberries, grapes, highbush blueberries, peaches, pears and plums established more than 1 year; blackberries, loganberries and red raspberries; inter-row spraying in strawberries; stale seedbed technique for vegetables and field crops; inter-row directed chemical weeding for vegetable fields and established nursery crops; asparagus; potatoes; established alfalfa and bird's-foot trefoil; pasture renovation; zero tillage corn; conifer control; turf renovation; chemical mowing weed control in non-crop land; aquatic weed control. **Sensitive Weeds:** Non-selective — affects all green plants. **Uptake and Translocation:** Absorbed by foliage and green bark; little or no translocation. **Basis of Selectivity:** All green plant tissue is sensitive. Less effective on plants with a very waxy cuticle and linear leaf shape such as nut sedge. Safe on mature (non-green) bark of woody plants. **Application Methods:** Postemergence. Broadcast, or directed spray to avoid contacting leaves or bark of desirable plants. Apply when weeds are less than 15 cm high. Better results are usually obtained if application is made on a dull or cloudy day, or in the evening. **Residual Activity:** Essentially no residual activity in soil. Will persist in organic material such as mulches or turf thatch; therefore, do not reseed these areas for 5 days. More than one application per season may be necessary, especially for perennial weeds. **Unique Characteristics:** Inactivated by adsorption to soil particles.

## PEBULATE

**Trade Name:** TILLAM. **Chemical Family:** Thiocarbamate. **Crop and/or Non-Crop Registrations:** Tobacco, tomatoes, red beets and sugarbeets. **Sensitive Weeds:** barnyard grass, crab grass, green foxtail, yellow foxtail, wild oats, yellow nut sedge, horsetail, lamb's-quarters, prostrate pigweed, purslane, redroot pigweed. **Uptake and Translocation:** Absorbed by roots, hypocotyl and seed. Translocated upward to growing point. **Basis of Selectivity:** Tolerant species degrade herbicide. Also food reserves in seed allow seedling to outgrow chemical effect. **Application Method:** Preplant incorporated. May be applied using water or liquid fertilizer as the carrier. Dry fertilizers may also be used as the carrier when impregnated by a licenced fertilizer dealer. Incorporate uniformly into the soil by setting the incorporation equipment (i.e., tandem disks, field cultivator, with sweep teeth or vibrating shank s-tine cultivator) to work soil approximately 10 cm deep followed by a levelling device. Irrigation (approximately 0.6 cm) can also be used to incorporate. When application and incorporation are separate operations, application should be to a dry soil surface. **Residual Activity:** Provides season-long weed control without soil residues the following season. **Unique Characteristics:** Rainfall is not required for activation. Leaching is not significant, even with a heavy rainfall.

## PENDIMETHALIN

**Trade Name:** PROWL. **Chemical Family:** Dinitroaniline. **Crop and/or Non-crop Registrations:** Onions and field corn. **Sensitive Weeds:** Green foxtail, yellow foxtail, crab grass, barnyard grass, fall panicum, common chickweed, lamb's-quarters and pigweed. **Uptake and Translocation:** Weeds are controlled as they germinate. Translocation is not significant and emerged weeds are not controlled. **Basis of Selectivity:** No significant uptake or translocation by the crop. **Application Methods:** Onions: postemergence to the crop at loop and 2-leaf stage. Field corn: preemergence and early postemergence. For preemergence application, pendimethalin may be applied in water or liquid fertilizer. A fertilizer compatibility test should be carried out using pendimethalin and any of its registered tank-mix partners. Early postemergence application may only use water as a carrier. **Residual Activity:** Persistence depends on weather conditions (more persistent under dry conditions). Only registered crops may be planted in the year of application. Soybeans and corn may be planted the year following application in corn. Days to harvest restriction: 100 days. **Unique Characteristics:** Strongly adsorbed to soil particles. Most effective when rain is received within 7 days of application. For onions, application at both growth stages is required for season-long control. Tank mixes in corn or sequential application of other herbicides in onions and corn are required for broad-spectrum weed control. Registered for dry bulb onions grown on muck soil only. DO NOT graze treated fields or feed treated foliage to livestock prior to 100 days after PROWL application.

## PHENMEDIPHAM

**Trade Name:** SPIN-AID. **Chemical Family:** Phenylcarbamate. **Crop and/or Non-Crop Registrations:** Red (table) beets. **Sensitive Weeds:** Lamb's-quarters, wild buckwheat, green foxtail, yellow foxtail, mustard. **Uptake and Translocation:** Phenmedipham is absorbed by the leaves where it acts by inhibiting the Hill reaction in the chloroplasts of leaf cells. **Application Method:** Postemergence. **Residual Activity:** Half-life of phenmedipham is approximately 25 days. **Unique Characteristics:** Phenmedipham may injure beets that are under stress. It may cause temporary growth retardation and/or chlorosis or tip-burn on red beets. Beets usually resume normal growth within 10 days.

## PROMETRYNE

**Trade Name:** GESAGARD **Chemical Family:** S-triazine. **Crop and/or Non-Crop Registrations:** Carrots, peas, leeks and transplanted celery. **Sensitive Weeds:** Lamb's-quarters, lady's-thumb, corn spurry, pigweed, wild mustard, purslane, eastern black nightshade, chickweed, hemp-nettle and green foxtail. **Uptake and Translocation:** Absorbed through foliage and roots. Translocated upwards through xylem, accumulating in the apical meristems. **Basis of Selectivity:** Metabolized by tolerant plants and to a lesser extent by sensitive plants, although this is not thought to be the major selective mechanism. **Application Methods:** Preemergence or early postemergence (before weeds are 5 cm high). Apply before carrots or peas emerge. Apply 7–14 days after celery is transplanted. **Residual Activity:** About 6–8 weeks. A fall cover crop of rye or oats may be sown on the treated land in the same season.

## PROPYZAMIDE

**Trade Name:** KERB. **Chemical Family:** Amide. **Crop and/or Non-Crop Registrations:** Alfalfa, bird's-foot trefoil, woody nursery stock, lettuce, apples, pears, lowbush blueberries. **Sensitive Weeds:** Perennial grasses including quack grass, annual grasses, volunteer cereals and common chickweed. **Uptake and Translocation:** Taken up by plant roots and translocated to the foliage. Little foliar absorption. **Basis of Selectivity:** Faster degradation in tolerant species. **Application Methods:** Preemergence to annual weeds. Postemergence control of perennial grasses when applied in the fall. Apply in the fall from late September to early November when the soil temperature is low but above freezing, and soil moisture is high. **Residual Activity:** Persistence is variable (2–9 months), depending on soil type and climatic conditions. Decomposition of the herbicide is slow at temperatures below 15°C but accelerates at temperatures above this level. Persistence is greatest in sandy soils with low organic matter. **Unique Characteristics:** Rainfall or irrigation is required after application to move the herbicide into the root zone for uptake by perennial grasses and germinating annual grasses.

## PROSULFURON

**Trade Name:** PEAK. (Available only in PEAKPLUS co-pack)

## PYRAZON

**Trade Name:** PYRAMIN FL. **Chemical Family:** Pyridazinone. **Crop and/or Non-Crop Registrations:** Sugarbeets and table beets. With NORTRON on sugarbeets. **Sensitive Weeds:** Annual nightshades, chickweed, knotweed, lady's-thumb, lamb's-quarters, oak-leaved goosefoot, prostrate pigweed, purslane, ragweed, redroot pigweed, shepherd's-purse, smartweed, stinkweed, wild buckwheat, wild carrot (seedling), wild mustard, wormseed mustard and yellow rocket (seedling). **Uptake and Translocation:** Can be taken up by both roots and leaves, but translocation is upward to leaves where it inhibits photosynthesis. **Basis of Selectivity:** Metabolism by tolerant species. **Application Methods:** Preplant incorporated, preemergence or postemergence after the second-true-leaf stage of the beets. **Residual Activity:** Average persistence is about 4–8 weeks in soil, depending on soil moisture and temperature. Residue carryover problems are unlikely. **Unique Characteristics:** With preemergence applications, at least 1.25 cm of rainfall is required for good weed control. Combinations of pyrazon and TCA are most useful where both annual broadleaf weeds and grasses are a problem. These treatments may not be effective on high organic soils or dry soils (i.e., muck soils or with late planted beets when soils are drier). Under these circumstances, postemergence applications of pyrazon plus TCA as a band over the row may be most effective. However, to be selective and effective the chemicals must be applied after the cotyledons of the beets are 2.5 cm long and before the weeds have reached the 4-true-leaf stage (10 cm). Where TCA has been used, beet tops should not be fed to livestock. TCA residues in the soil can be a problem for some crops such as corn.

## PYRIDATE

**Trade Name:** LENTAGRAN. **Chemical Family:** Phenyl pyridazine. **Crop and/or Non-Crop Registrations:** Cabbages, corn (field, sweet, seed), tomatoes. **Sensitive Weeds:** Annual broadleaf weeds (1- to 4-leaf stage) including triazine-resistant species, certain annual grasses (1- to 3-leaf stage) when the weeds are actively growing. Pyridate alone: lamb's-quarters and redroot pigweed. For pyridate plus atrazine on corn and for pyridate plus metribuzin on tomatoes: lamb's-quarters, redroot pigweed, nightshade, purslane, ragweed (common), wild mustard, velvetleaf and suppression of buckwheat (wild), lady's-thumb (smartweed), barnyard grass, crab grass (hairy), foxtail (green and yellow). Where heavy annual grass pressure is a problem, use a specific preemergence grass herbicide. **Uptake and Translocation:** Rapidly absorbed by leaves and acts as a contact only. **Basis of Selectivity:** It penetrates into both sensitive and tolerant plants but is quickly metabolized and inactivated in tolerant crops such as corn. In sensitive weeds, activity is evident by marginal yellowing, followed by yellowing and browning of the entire leaf. This visible evidence generally occurs within 4–7 days after application. Activity is more rapid at higher temperatures and under good growing conditions. Weed control under drought conditions may be decreased. **Application Method:** Postemergence. Sprays can be applied overall on corn and directed on transplanted tomatoes. **Residual Activity:** None. **Unique Characteristics:** Combination with triazine herbicides improves total weed control. The stage of the weed, not the stage of the corn, determines application date. Tomatoes will show temporary yellowing, which is reduced by directing the spray to the bottom one-third of well-established tomato plants. Uptake by leaves is very rapid and rainfall shortly after application (1–2 hr) has little effect on the degree of control.

## QUIZALOFOP-P-ETHYL

**Trade Name:** ASSURE II. **Chemical Family:** Aryloxyphenoxypropionate. **Crop and/or Non-Crop Registrations:** Canola, flax, snap beans, seed alfalfa, soybeans and sugarbeets. **Sensitive Weeds:** Green foxtail, barnyard grass, fall panicum, old witch grass, proso millet, wild oats, volunteer cereals and volunteer corn. **Uptake and Translocation:** Rapidly absorbed and readily translocated in both the xylem and phloem from the treated foliage to the root system and growing points of the plant. **Basis of Selectivity:** Disruption of fatty acid biosynthesis leading to increased permeability and cellular disruption in sensitive plants. Rapid metabolism of the active herbicide in tolerant species. **Application Methods:** Postemergence. **Residual Activity:** Rapid microbial degradation and essentially no soil activity. **Unique Characteristics:** Apply with CANPLUS-411 at 5–10 L per 1,000 L of spray solution or SURE-MIX at 5 L per 1,000 L of spray solution. Tank-mix with PINNACLE or PINNACLE + BASAGRAN FORTE for control of broadleaf weeds.

## RIMSULFURON

**Trade Name:** ELIM EP, PRISM. **Chemical Family:** Sulfonylurea. **Crop and/or Non-Crop Registrations:** ELIM EP — Field corn. Not for use on sweet or seed corn. PRISM — Potatoes, transplanted processing tomatoes. Not for use on potatoes grown for seed. **Sensitive Weeds:** Green foxtail, fall panicum, barnyard grass, redroot pigweed (including triazine-resistant), hairy nightshade, suppression of yellow foxtail, witch grass, lamb's-quarters. **Uptake and Translocation:** Following foliar application, rimsulfuron is rapidly absorbed through the leaves and translocated in both xylem and phloem. **Basis of Selectivity:** Inhibition of acetolactate synthase (ALS) enzyme in susceptible plants leads to a rapid cessation of cell division and growth. Tolerant species rapidly convert rimsulfuron to non-phytotoxic metobolites. **Application Method:** Postemergent, within the spike–3-leaf stage of corn. Prior to initiation of flowering in potatoes. **Residual Activity:** Rapid soil microbial degradation. **Unique Characteristics:** Emerged grasses will be controlled by rimsulfuron, but subsequent germinating grass weeds will not be controlled. A non-ionic surfactant must be added at 0.2% v/v. Typical symptoms of plant death (chlorosis, necrosis) occur 5–10 days after application, depending on growing conditions. tank-mix with dicamba for control of broadleaf weeds in corn. Do not apply rimsulfuron to corn that has been treated with an organophosphorous soil insecticide (i.e., COUNTER, LORSBAN, THIMET, CYGARD or DI-SYSTON). Do not use rimsulfuron on corn hybrids with a crop heat unit (CHU) rating of 2,500 or less, or in geographic regions with 2,500 or less average seasonal CHUs. Rimsulfuron should not be sprayed for weed control in fields planted with some hybrids. SEE THE LABEL FOR LIST.

## S-METOLACHLOR

**Trade Names:** DUAL MAGNUM, DUAL II MAGNUM. **Chemical Family:** Acetanilide. **Crop and/or Non-Crop Registrations:** Corn, soybeans, snap beans (yellow and green only), dry beans (white, kidney and pinto only), lima beans, transplanted cole crops (cabbages, cauliflower, broccoli), transplanted tomatoes, potatoes, sugarbeets, processing peas, rutabagas and sweet white lupins, apples, apricots, cherries, peaches, pears and plums. **Sensitive Weeds:** Large and smooth crab grass; witch grass; barnyard grass; fall panicum; giant, green and yellow foxtail; yellow nut sedge; American nightshade, Eastern black nightshade. **Uptake and Translocation:** Absorbed by germinating grasses mainly through shoot just above seed. Absorbed by germinating broadleaf weeds through roots and shoots. **Basis of Selectivity:** Metabolized by tolerant species. **Application Methods:** Early preplant, preplant incorporated and preemergence. Early postemergence on corn (spike to 2-leaf stage of corn). Incorporation equipment should be set to work the soil 10 cm deep with a disc operating at 6–10 km/h or a vibrating shank cultivator at 10–13 km/h; one incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application. **Residual Activity:** Activity will normally be maintained for 10–14 weeks. **Unique Characteristics:** The rate required depends on weed pressure (higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Winter cereals may be planted 4–5 months after metolachlor application. Many tank-mix combinations are registered on various crops. Do not use on muck soils or coarse-textured soils low in organic matter. DUAL II MAGNUM contains benoxacor, a chemical that enhances the corn plant's ability to metabolize s-metolachlor, thereby preventing corn injury even under adverse environmental conditions.

## S-METOLACHLOR/ATRAZINE

**Trade Name:** PRIMEXTRA II MAGNUM. **Chemical Family:** Acetanilide/s-triazine. **Crop and/or Non-Crop Registrations:** Corn (ensilage, field, seed and sweet). **Sensitive Weeds:** Germinating annual broadleaf weeds and annual grasses such as American nightshade, eastern black nightshade, lady's-thumb, lamb's-quarters, wild mustard, purslane, prostrate pigweed, redroot pigweed, wild buckwheat, smartweed, ragweed, crab grass, barnyard grass, green foxtail, yellow foxtail, giant foxtail, witch grass and fall panicum. Yellow nut sedge can be controlled with a preplant incorporated application. **Uptake and Translocation:** Absorbed by germinating grasses mainly through shoot just above seed. Absorbed by germinating broadleaf weeds through roots and shoot. **Basis of Selectivity:** Metabolized by tolerant species. **Application Methods:** Early preplant, preplant incorporated, and preemergence. Early postemergence on corn (spike to 2-leaf stage of corn. Incorporation equipment should be set to work the soil 10 cm deep with a disc operating at 6–10 km/h or a vibrating shank cultivator at 10–13 km/h.). One incorporation is sufficient and need not be immediate. Rainfall within 10 days is required for maximum activity of the preemergence application. S-metolachlor/atrazine may be applied in nitrogen solutions or liquid fertilizers for preplant incorporated or preemergence weed control. Dry bulk granular fertilizers may be impregnated with metolachlor/atrazine for preplant incorporation. **Residual Activity:** Activity will normally be maintained for 10–14 weeks; late-germinating fall panicum will not be controlled. Soybeans, white beans, oats or barley may be planted the following spring. **Unique Characteristics:** The rate required depends on weed pressure (higher rate for heavier weed pressure). Yellow nut sedge control requires a preplant incorporated application. Will not control triazine-resistant weed species. Contains atrazine in low amounts, which may carry over in a dry year. Is effective over a wide range of soil types and has a good margin of crop safety. Perennial weeds are not controlled. Primextra II MAGNUM contains benoxacor, a chemical that enhances the corn plant's ability to metabolize s-metolachlor, thereby preventing corn injury even under adverse environmental conditions.

## SETHOXYDIM

**TRADE NAME:** POAST ULTRA. **Chemical Family:** Cyclohexanedione. **Crop and/or Non-Crop Registrations:** Canola (rapeseed), flax, soybeans, dry beans, snap beans, peas, onions, tomatoes, potatoes, sweet potatoes, pumpkins, squash, cucumbers, alfalfa, lima beans, faba beans, adzuki beans, mung beans, buckwheat, creeping red fescue, garlic, broccoli, cabbages, cauliflower, peppermint, spearmint, apples, apricots, cherries, peaches, pears, plums, highbush blueberries, cranberries, strawberries and sethoxydim-resistant corn. **Sensitive Weeds:** Annual grasses (wild oats, foxtails, barnyard grass, large crab grass, proso millet, fall panicum and witch grass), volunteer corn and cereals and quack grass. **Uptake and Translocation:** Absorbed by foliage. Translocated upwards and downwards in plant. **Basis of Selectivity:** Degraded by tolerant species (broadleaf plants). **Application Methods:** Postemergence to actively growing annual grasses in the 1- to 6-leaf stage and quack grass in the 1- to 3-leaf stage. Use flat fan nozzles and add MERGE adjuvant to the spray mix. Alternatively, ASSIST OIL CONCENTRATE or ammonium sulphate plus ASSIST OIL CONCENTRATE may be used. Other postemergence herbicides that are not recommended as tank-mix combinations on the label must be applied at least 4 days before or after sethoxydim application. Aerial application is also registered. **Residual Activity:** Essentially none. A second application and/or cultivation may be necessary to control grasses that emerge after treatment. **Unique Characteristics:** Susceptible grasses, when sprayed, stop growing immediately and then gradually turn yellow to purple to brown over a period of 7–21 days, depending on growing conditions and crop competition. Rainfall within 1 hour after application may reduce effectiveness. If treated grasses are stressed (drought, flooding, prolonged cool temperatures), control will be delayed or reduced.

## SIMAZINE

**Trade Names:** PRINCEP NINE-T, SIMADEX, SIMAZINE, SIMAZINE 480. **Chemical Family:** S-triazine. **Crop and/or Non-Crop Registrations:** Corn, established asparagus, bird's-foot trefoil, raspberries, loganberries, blackberries, highbush blueberries, alfalfa, apples, apricots, cherries, peaches, pears and plums established for 1 year or more; grapes established for 3 or more years; shelterbelts established for at least one growing season (caragana, green ash, Siberian elm, American elm and Manitoba maple); new or established Christmas tree and woodland plantations (2 year or older white pine and balsam fir); woody ornamentals and nursery stock established for at least 1 year (cedar, barberry, apple, flowering crab apple, box wood, cotoneaster, dogwood, holly, rose, yews, chamaecyparis, hemlock, juniper, multiflora rose, peony; spruce, mugho pine, black walnut and white ash); nursery container stock (cedar, juniper, yew); aquatic weed control; non-crop land. Conifer site preparation before planting of fir, pine and spruce (Princep NINE-T only). **Sensitive Weeds:** Annual broadleaf weeds such as pigweed, lady's-thumb, lamb's-quarters, purslane, ragweed, volunteer clover, wild buckwheat, smartweed, plantain and groundsel; annual grasses such as barnyard grass, crab grass, wild oats and yellow foxtail (triazine-resistant biotypes of foxtail, lamb's-quarters, pigweed and groundsel will not be controlled); most perennial species starting freshly from seed. **Uptake and Translocation:** Absorbed by roots; little or no foliar absorption; translocated upwards in xylem, accumulating in apical meristem and leaves with napropamide on new plantings of apples, apricots, cherries, plums, peaches and pears. **Basis of Selectivity:** Some species, such as corn, metabolize simazine. In most crops, selectivity is based on the roots of the crop plants being deeper than the depth to which simazine leaches. **Application Methods:** Preplant incorporated (to a depth of 2.5 cm) or preemergence in corn; preemergence in other crops. Broadcast or band application. In fruit crops, apply a 1 m wide band under the plants; cultivate or sod the area between the rows. For aquatic weed control, apply as a draw-down treatment or water-volume application in drainage ditches and ponds with no water flow-through. **Residual Activity:** Soil residues may persist for more than 1 season. After spraying with simazine, do not plant any crop in the treated area in the same year except corn. Where rates in excess of 2 kg/ha have been applied, do not plant rotational crops in the following year; soils should be tested if there is any question of excessive residues remaining. **Unique Characteristics:** Needs sufficient moisture to be activated. Should be applied only once per season. To avoid build-up of resistant weeds, simazine should be rotated with other non-triazine residual herbicides. Simazine is more persistant than atrazine. Where rainfall is sufficient to cause erosion, soil containing simazine may wash to lower areas of land and injure existing or subsequent crops.

## SURFACTANT

See *Notes on Adjuvants for Vegetables*, on page 185.

## TERBACIL

**Trade Name:** SINBAR. **Chemical Family:** Uracil. **Crop and/or Non-Crop Registrations:** apples, apricots, cherries, highbush blueberries, peaches, pears, plums, spearmint, peppermint and strawberries; with napropamide on new plantings of apples, apricots, cherries, plums, peaches and pears. **Sensitive Weeds:** Barnyard grass, bluegrass, crab grass, foxtail, chickweed, cheat grass, perennial rye grass, wild barley, mustard, prickly lettuce, stinkweed, annual sow-thistle, henbit, lamb's-quarters, pigweed, purslane and ragweed. Partial control of quack grass, horsenettle, vetch and yellow nut sedge. **Uptake and Translocation:** Uptake is mostly through roots, although partially through foliage and stem. Translocation is upward into leaves. **Basis of Selectivity:** Used only on established plantings so that roots of crop are below depth to which chemical penetrates. May also be slower translocation and faster degradation in tolerant species. **Application Methods:** Apply to the soil surface in 200–1,000 L water/ha. If weed growth is present in apples, paraquat may be mixed with spray. Rates for strawberries are considerably lower and can be applied in spring, post-harvest or late fall. Control of perennial grasses may be improved by cultivation prior to treatment. **Residual Activity:** May be up to 2 years. Residues are likely to be higher on heavier soil types if higher rates and repeated applications are used. **Unique Characteristics:** Moisture is necessary to activate the chemical within 2 weeks after application. Do not apply on soils with less than 1% organic matter, nor on eroded soil areas. Use lower rates on soils with 1%–2% organic matter. Do not apply on weak or diseased strawberry plants.

## TRIALLATE

**Trade Name:** AVADEX BW **Chemical Family:** Thiocarbamate. **Crop and/or Non-Crop Registrations:** Spring wheat and barley, flax, rapeseed, sugarbeets, mustard and dry peas. **Sensitive Weeds:** Wild oats. **Uptake and Translocation:** Absorbed mainly by the coleoptile of wild oats. **Application Methods:** Postplant incorporated (spring wheat and barley). Preplant incorporated (barley, flax, rapeseed, sugarbeets, mustard and dry peas). For postplant treatment of the cereals, the spray is applied to the soil after the crop is seeded and then thoroughly worked into the soil by harrowing twice, the second harrowing at right angles to the first; the crop should be seeded uniformly, deep enough so it is not disturbed by the harrow. For preplanting treatments, the chemical is sprayed on the soil surface and worked into the top 5–8 cm of soil with a disk or cultivator implement. The crop can be seeded any time after treatment. In all treatments, the chemical should be worked into the soil within 2 hours after spraying. **Residual Activity:** Half-life in soil of approximately 6–8 weeks.

## TRIFLURALIN

**Trade Names:** BONANZA 400, RIVAL, TREFLAN EC. **Chemical Family:** Dinitroaniline. **Crop and/or Non-Crop Registrations:** Soybeans, dry beans (white or kidney), faba beans, snap beans, lima beans, black beans, canola (rapeseed), triazine-tolerant canola (variety of O.A.C. Triton, pedigreed seed only), sunflowers, turnips, peas (field and canning), direct-seeded alfalfa; transplants of tomatoes, peppers, Brussels sprouts, broccoli, cabbages and cauliflower; carrots, crambe, direct-seeded cabbages and cauliflower, annual flowers, woody ornamental plantings and field-grown nursery stock, perennials, established shelterbelts, strawberries. **Sensitive Weeds:** Effective on most annual grasses and will provide good control of pigweed and lamb's-quarters, including the triazine-tolerant biotypes of these weeds. **Uptake and Translocation:** No significant absorption or translocation of trifluralin in crops grown in soil treated with trifluralin. Susceptible weeds are controlled as they germinate. Established weeds are not controlled. **Basis of Selectivity:** Physiological growth processes associated with seed germination. **Application Methods:** Preplant incorporated. Apply in 100–300 L of water/ha. Use lower rate of the chemical on sandy soils and increased rate for loam-to-clay soils. Do not use on highly organic soils (muck, peat or black sands above 15% organic matter). Incorporate twice in cross directions using a tandem disc (7–10 km/h) or tine cultivator (10–13 km/h) set to work 8–10 cm deep. The first incorporation should be done as soon as possible after application but may be delayed 8–24 hours, depending on label directions. The second incorporation is recommended anytime before planting. Activated upon incorporation; rainfall is not required. **Residual Activity:** Recommended application rates provide season-long weed control. Succeeding crops, even fall-seeded grain crops planted in soil that received trifluralin the preceding spring, will not be injured under normal conditions. **Unique Characteristics:** Strongly adsorbed to soil particles and shows negligible leaching. Organic matter and clay content influence application rate. Does not control ragweed, annual nightshades or mustards; lady's-thumb may escape.

## TRIFLUSULFURON-METHYL

**Trade Name:** UPBEET. **Chemical Family:** Sulfonylurea. **Crop and/or Non-Crop Registrations:** Sugarbeets. With BETAMIX on sugarbeets. **Sensitive Weeds:** Redroot and green pigweed, velvetleaf. **Uptake and Translocation**: Following foliar application, the herbicide is rapidly absorbed and translocated in both the xylem and phloem to growing points of sensitive weeds. **Basis of Selectivity:** Inhibition of acetolactase synthase (ALS) enzyme in susceptible plants that leads to a rapid cessation of cell division and plant growth. Tolerant species rapidly metabolize the herbicide into non-phytotoxic metabolites. **Application Methods:** Postemergence. **Residual Activity:** None. **Unique Characteristics**: Must be applied with an approved adjuvant system including 0.2% v/v non-ionic surfactant. Addition of 28% urea ammonium nitrate (U.A.N.) at 2 L/ha will improve weed control. Plant death of target weeds may take from 1–3 weeks for visual symptoms to develop. Symptoms develop more quickly under favourable growing conditions.

## Table 7–2. Adjuvants Used in Ontario

| Brand and Trade Names[1] | Type of Adjuvant | Chemical Composition | Guaranteed Active | Ontario Schedule | Winter Storage[2] | Manufacturer/ Agent Code |
|---|---|---|---|---|---|---|
| 38-F | drift retardant | polyacrylamide | 82% | 3 | C | UAG |
| AGRAL 90 | non-ionic surfactant | nonylphenoxy polyethyoxyethanol | 90% | 2 | C | NOR |
| AG-SURF | non-ionic surfactant | nonylphenoxy polyethyoxyethanol | 92% | 2 | C | INT |
| AMIGO | surfactant | phosphate ester | 30% | 2 | C | AET |
| ASSIST OIL CONCENTRATE | mineral oil/surfactant (non-herbicidal) | paraffin base mineral oil + surfactant blend | 83% + 17% | 3 | C | BAZ |
| BASF LIQUID AMMONIUM SULPHATE | liquid fertilizer | ammonium sulphate | 490 g/L | 6 | A | BAZ |
| CANPLUS 411 | mineral oil/surfactant (non-herbicidal) | paraffin base mineral oil + surfactant blend | 83% + 17% | 6 | C | ATC |
| CHARGE | mineral oil/surfactant (non-herbicidal) | paraffin base mineral oil + surfactant blend | 83% + 17% | 6 | C | ZNA |
| CITOWETT PLUS | non-ionic spreader sticker surfactant | ocylphenoxy-polyethoxy ethanol | 50% | 3 | C | BAZ |
| COMPANION | non-ionic surfactant | ocylphenoxy-polyethoxy-(9) ethanol | 70% | 3 | C | ROH |
| CO-OP EMULSIFIABLE SPRAY OIL | mineral oil (non-herbicidal) | mineral oil + emulsifier | 98.5% + 1.5% | 3 |  | INT |
| CORN OIL | mineral oil (non-herbicidal) | paraffin base mineral oil + surfactant blend | 98.8% + 1.2% |  | C | UAG |
| ENHANCE | cationic surfactant with non-ionic component | tallow fatty acid amine ethoxylate and nonylphenoxy-polyethoxy ethanol | 780 g/L | 2 | A | DWE |
| FIGHTER F | antifoamer/defoamer | dimethylpolysiloxane |  | 3 |  | UAG |
| HALT | defoamer | silicone base, neutral | 30% |  | A | DWE |
| IPCO OIL CONCENTRATE | mineral oil (non-herbicidal) | paraffin base mineral oil + surfactant blend | 83% + 17% | 3 | C | INT |
| KORNOIL | mineral oil (non-herbicidal) | mineral oil + emulsifier | 98.5% + 1.5% | 3 | C | VAR |
| KORNOIL CONCENTRATE | mineral oil/surfactant (non-herbicidal) | paraffin base mineral oil + surfactant blend | 85% + 15% | 3 | C | VAR |
| LI700 | non-ionic surfactant & pH adjuster acidifier | phosphatidylcholine, methylacetic acid, alky polyoxyethylene ether | 80% | 3 | C | UAG |
| MERGE | surfactant/solvent | surfactant blend + solvent (petroleum hydrocarbons) | 50% + 50% | 3 | B | BAZ |
| NALCO-TROL | drift control agent | polyvinyl polymer | 30% | 3 |  | NLC |
| SIDEKICK | non-ionic liquid spreader/activator | alkylarylpolyoxyethylene glycols, free fatty acids & isopropyl alcohol | 900 g/L | 3 | C | NOR |
| SPRAY ADJUVANT DEFOAMER | defoamer | demethylpoly-silozane |  |  |  |  |
| SPRAYCO OIL CONCENTRATE | mineral oil/surfactant (non-herbicidal) | paraffin base mineral oil + surfactant blend | 85% + 15% | 6 | C | SWC |
| SPRAYCO PREMIUM MINERAL OIL | mineral oil (non-herbicidal) | mineral oil + emulsifier | 98.5% + 1.5% | 6 | C | SWC |
| SUPER SPREADER STICKER | non-ionic spreader sticker surfactant | ocylphenoxy-polyethoxy ethanol | 50% | 3 | C | UAG |
| SUPERIOR OIL CONCENTRATE | mineral oil (non-herbicidal) | paraffin base mineral oil + surfactant blend | 83% + 17% | 6 |  | BAT, AET UAP |
| SURE-MIX | petroleum oil/surfactant (non-herbicidal) | paraffinic petroleum oil + surfactant blend | 60% + 35.6% | 6 | A | DUQ |
| SURF 92 | non-ionic surfactant | nonylphenoxy polyethyoxyethanol | 92% | 2 | C | WBR |
| SYLGARD 309 | organosilicone, non-ionic | silicone polyether | 76% | 3 | C | DCS |
| TURBOCHARGE | mineral oil/surfactant (non-herbicidal) | paraffin base mineral oil + surfactant blend | 50% + 39.5% | 3 | C | ZNA |

[1] Mention of a brand or trade name in this table does not constitute a guarantee or warranty of the product by the Ontario Weed Committee. Neither does this use signify that these products are approved to the exclusion of comparable products. All trade names are capitalized.

[2] Winter storage: A = Do not allow to freeze; B = Preferably should not freeze. If frozen, return to 10°C–20°C and agitate thoroughly; C = not usually damaged by freezing. Store in a cool, dry place.

# Notes on Adjuvants for Vegetables

## Introduction

An adjuvant is any substance added to a spray solution to modify and enhance the effectiveness of the herbicide.

Adjuvants are an important part of the spray solution. If they are omitted, weed control can be reduced. Some products have adjuvants formulated into the product while other adjuvants are added by the user. The selection of adjuvants is key to getting the right balance between maximizing weed control and minimizing crop injury. In some cases, the rate of adjuvant will vary depending on conditions of weather, crop stage, weed species, water quality, etc. Some herbicide labels recommend particular adjuvant products and some recommend particular types of adjuvants. Always use adjuvants as directed on the product label.

Most adjuvant recommendations in this publication are listed as the amount (in litres) that would be added to 1,000 litres (L/1,000 L) of spray solution. If you wish to convert to % volume/volume (v/v) use the following conversion:

10 L/1,000 L = 1% v/v

There are two broad categories of adjuvants:

- activators and spray modifiers
- utility modifiers

### *Activators and Spray Modifiers*

- **Surfactants** (also known as "surface active agents") are the largest class of adjuvants. Surfactants can be non-ionic, anionic, cationic or amphuteric. Most surfactants are non-ionic (NIS); they do not ionize. A NIS is used to enhance herbicide penetration into a waxy cuticle. Wetting agents and detergents are primarily anionic and when ionized in solution, the water-soluble portion is negatively charged. Cationic surfactants exhibit a net positive charge in solution. Amphuteric surfactants can be either anionic or cationic. Cationic and amphuteric are not widely used in agricultural chemicals.
- **Oils** solubilize the waxy cuticle layer on a weed to increase spray penetration through the leaf cuticle. Oils can be refined mineral oils (petroleum-based) or seed oils. Seed oils can be categorized as triglycerides, methylated seed oils (MSO) or crop oil concentrates (COC). Crop oil concentrates are a combination of seed oil and surfactants.
- **Spreaders** are wetting agents that reduce the surface tension to create better contact between the spray solution and the treated surface (leaf, etc). A **sticker** increases the herbicide adhesion to the leaf surface.

### *Utility Modifiers*

- **Compatibility** agents improve mixing, especially when using a liquid fertilizer carrier.
- **Drift control** agents increase the droplet size to reduce drift.
- **Anti-foaming** agents are used to reduce foaming in the spray tank.
- **Foaming** agents are used with specialized equipment to produce and apply a foam.
- **Buffering** agents can be used to enhance solubility or adjust pH.

### *Note*

The following notes should be considered with the recommendations given later in this publication. Additional information on use, toxicity and safety precautions is given here. With a few exceptions, the adjuvants are listed under their trade or product name. See Table 7–2, *Adjuvants Used in Ontario*, on page 184, for a summary of adjuvants listed in this publication.

Complete information on each adjuvant is available on the product label that is located on the product container. The federal Pest Management Regulatory Agency also lists pesticide labels on their Web site at: http://64.26.129.82/search/queryhit.htm.

Many pesticide manufacturers also list product labels and/or Material Safety Data Sheets (MSDS) on their Web sites, listed in Appendix B, *Pest Control Product Companies*, on page 281.

## AGRAL 90

**Type of Adjuvant:** Non-ionic surfactant. **Chemical Composition:** Nonylphenoxy polyethyoxyethanol 90%. **Registered Uses:** For use with diquat, paraquat, glyphosate, imazethapyr, rimsulfuron, nicosulfuron/rimsulfuron and for washing sprayer tanks and equipment. **Benefit:** Improves chemical effectiveness. **Mode of Action:** It is a wetting and spreading agent that improves coverage of spray mixes. **Mixing:** Use 250–1,000 mL/1,000 L of spray as specified on label. Will mix with all types of water. Add AGRAL 90 to the spray mixture and agitate thoroughly. **Unique**

**Characteristics:** Do not exceed the recommended rates of AGRAL 90 as too much wetting agent can lead to loss of spray due to excessive run-off.

## AG-SURF

**Type of Adjuvant:** Non-ionic surfactant. **Chemical Composition:** Nonylphenoxy polyethyoxyethanol 92%. **Registered Uses:** For use with glyphosate, imazethapyr and fluazifop-p-butyl. **Benefit:** Improves chemical effectiveness. **Mode of Action:** It is a wetting and spreading agent that improves coverage of spray mixtures. **Mixing:** For use with ROUNDUP: when applying the 2.5 L/ha of water, add AG-SURF at 0.5% (0.50 L/100 L water) to maintain adequate surfactant concentration. For use with ROUNDUP to control annual grasses and broadleaf weeds for minimum or zero-till: use 350 mL/ha plus ROUNDUP at 1.1 L/ha in 50–100 L/ha of clean water. For use with FUSILADE 250EC: add 100 mL of AG-SURF for each 100 L of spray solution (0.1%). An antifoaming agent may be required to reduce foaming. **Unique Characteristics:** Do not exceed recommended rates of AG-SURF, as too much may reduce the effectiveness of the herbicide due to excessive run-off. Consult product label for full directions.

## AMIGO

**Type of Adjuvant:** Surfactant. **Chemical Composition:** 30% phosphate ester surfactant. **Registered Uses:** For use with clethodim and clethodim tank mixes. **Benefit:** Improves chemical effectiveness under varying environmental conditions. **Mode of Action:** Improves spreading of spray droplets on the leaf surface and increases contact area. Enhances penetration of herbicide through the leaf cuticle layer. **Mixing:** Half-fill spray tank with water and start agitation. Add the correct amount of herbicide, agitate and then add the correct amount of AMIGO with the remaining water. Continue to agitate.

## ANTIFOAMERS/DEFOAMERS

See BREAKER, right, FIGHTER F, FLAT-OUT, and HALT (page 187) and SPRAY ADJUVANT DEFOAMER (page 189).

## AQUASHADE

**Chemical Family:** Water-soluble dyes. **Crop and/or Non-Crop Registrations:** Contained golf course, farm and industrial ponds, fountains and aquariums. **Sensitive Weeds:** Filamentous algae and certain aquatic weeds. **Uptake and Translocation:** The dye filters wavelengths of sunlight, reducing the light intensity. **Application Methods:** May be added in a concentrated form from the shoreline or diluted form for larger areas. It is recommended to make the application early in the growing season before algae and weed growth develop. Mechanical removal of heavy vegetation is recommended before applying Aquashade if fish are present in the pond. **Residual Activity:** The effect lasts as long as the water keeps its blue colour. Additional Aquashade can be applied when the colour of the water fades or when the first new algae and weed growth is noticed. **Unique Characteristics:** It has no direct chemical action and will therefore not harm fish.

## ASSIST OIL CONCENTRATE

**Type of Adjuvant:** Mineral oil/surfactant (non-herbicidal). **Chemical Composition:** 83% paraffin base mineral oil plus 17% surfactant blend. **Registered Uses:** ASSIST OIL CONCENTRATE is registered for use with sethoxydim, BASAGRAN, bentazon/atrazine and atrazine. **Benefit:** The use of ASSIST results in improved post-emergence activity and a greater degree of consistency under varying environmental conditions. ASSIST will also aid in providing a faster weed kill. **Mode of Action:** Reduces the evaporation of spray droplets on the leaf surface leading to a longer period for penetration. Improves penetration through the leaf cuticle layer. ASSIST also aids in spreading a spray droplet on the leaf surface so that it covers a greater surface area. **Mixing:** Half-fill the spray tank with water and begin agitation. Add the desired amount of herbicide and continue filling. Add ASSIST last. After filling, continue agitation. Agitate thoroughly after any stoppage in spraying. **Unique Characteristics:** May cause increased temporary topical burn to crop plants under hot, humid weather conditions.

## BREAKER

**Type of Adjuvant:** Antifoamer/Defoamer. **Registered Uses:** To reduce foaming when preparing herbicide spray mixes. **Benefit:** Small quantities of BREAKER added before adding herbicides will prevent foam from forming. **Mixing:** Add 7 mL/500 L of spray mix. **Unique Characteristics:** Can be added after foam has formed but more time will be required to eliminate the foam.

## CANPLUS 411

**Type of Adjuvant:** Mineral oil/surfactant (non-herbicidal). **Chemical Composition:** 83% paraffin-base mineral oil plus 17% surfactant blend. **Registered Uses:** CANPLUS 411 is registered for use with ASSURE II. **Benefit:** The use of CANPLUS 411 results in improved postemergence activity and a greater degree of consistency under varying environmental conditions. **Mode of Action:** Reduces the evaporation of spray droplets from the leaf surface and decreases the surface tension of spray droplets, thus improving the penetration through the cuticle of leaf surfaces. **Mixing:** Add the required amount of water to spray tank with agitator running. Add

ASSURE II and when well mixed add 5–10 L of CANPLUS 411 for each 1,000 L of spray solution. **Unique Characteristics:** May cause increased temporary phytotoxicity to crop plants under hot humid weather conditions.

## CHOICE

**Type of Adjuvant:** Water conditioning agent. **Chemical Composition:** Blend of polyacrylic, hydroxy carboxylic, propionic acids, phosphate ester and ammonium sulfate. **Benefit:** Eliminates "hard water antagonism" and instability due to high pH. **Mode of Action:** Conditions water by sequestering or chelating hard water ions and by the reduction in pH. **Mixing:** 2.5–7.5 L/1,000 mL water.

## CITOWETT PLUS

**Type of Adjuvant:** Non-ionic spreader sticker surfactant. **Chemical Composition:** Octyl phenoxy poly polyethoxy ethanol 50%. **Registered Uses:** Corn/atrazine; sugarbeets and red beets/pyrazon; peas/bentazon. **Benefit:** Improves postemergence control of weeds that have reached their upper limit in size for susceptibility. **Mode of Action:** Causes the spray mix to form a continuous film on leaf surfaces; also makes herbicide more rainfast. **Mixing:** Half-fill tank with water; add herbicide with continuous agitation; complete filling of tank with water; add CITOWETT with continuous agitation. **Unique Characteristics:** Higher rates are required with hard water.

## COMPATABILITY AGENTS

See UNITE (page 189).

## CORNOIL

See *KORNOIL*, right.

## CORNOIL CONCENTRATE

See KORNOIL CONCENTRATE (page 188).

## DRIFT-CONTROL AGENTS

See entries for 38-F DRIFT RETARDANT and NALCO-TROL in Table 7–2, *Adjuvants Used in Ontario*, on page 184, and the section ON TARGET (page 188).

## FIGHTER F

**Type of Adjuvant:** Antifoamer-Defoamer. **Chemical Composition:** Dimethylpolysiloxane 10%. **Registered Uses:** To control foam in water, oil, fertilizer and pesticide spray mixtures. **Benefit:** Controls foam when mixing sprays, eliminates material waste, provides more accurate metering of agricultural sprays and eliminates foam overflow at fill site. **Mixing:** To control foam when mixing spray solution, add defoamer either just before or during addition of any other spray adjuvant. To cut existing foam, add defoamer to tank and recirculate solution until foam dissipates.

## FLAT-OUT

**Type of Adjuvant:** Defoamer. **Chemical Composition**: Dimethylpolysiloxane 18% Silicone base neutral. **Registered Uses:** To control foam formation or existing foam, use as premix or add while spray tank is being filled. **Benefit**: The reduction of foam allows for faster tank fill, ensures fill volumes are correct and reduces the possibility of chemical overflow, therefore ensuring a more accurate application. It also makes the cleaning process easier. **Mixing:** Add 5–10 ml per 100 L of solution. Adjust the amount required according to individual conditions. May be used before mixing to prevent foam, or after to cut foam. May be used with any herbicide unless contraindicated on the label.

## FOAM MARKERS

See TREKKER TRAX (page 189).

## HALT

**Type of Adjuvant:** Defoamer. **Chemical Composition:** Silicone base, neutral. **Registered Uses:** To reduce foaming when preparing herbicide spray mixes. **Benefit:** The reduction of foaming allows faster tank fill-ups, ensures correct fill volumes, reduces the possibility of chemical overflow and gives more accurate herbicide application. **Mixing:** Add 7 mL/500 L of spray mix. May be added to spray tank during filling to prevent foaming, or after to cut foam. **Unique Characteristics:** May be used with any herbicide unless contraindicated on the label.

## HERBICIDAL OIL

See *Notes on Herbicides for Vegetables*, on page 164, and the section MINERAL OIL (HERBICIDAL) (page 176).

## KORNOIL

**Type of Adjuvant:** Mineral oil (non-herbicidal). **Chemical Composition:** 98.5% mineral oil, 1.5% emulsifier. **Registered Uses:** (Crop/herbicide): Corn/atrazine. **Benefit:** Improved postemergence activity of atrazine. **Mode of Action:** Partially dissolves waxy cuticle of weeds allowing atrazine to penetrate more readily.

**Mixing:** Fill spray tank with water allowing space for subsequent addition of atrazine and oil; engage agitation and pour in premixed slurry of atrazine in water; add KORNOIL last. Avoid excessive agitation of the spray mix as this may cause coagulation or buttering out. **Unique Characteristics:** To prevent a build-up of oil in the sprayer, empty the tank as completely as possible before refilling. Some injury may occur if the crop is stressed (cold weather or hot, dry weather).

## KORNOIL CONCENTRATE

**Type of Adjuvant:** Mineral oil/surfactant (non-herbicidal). **Chemical Composition:** Paraffin-base mineral oil 85%, surfactant blend 15%. **Registered Uses:** To be blended with atrazine/water mixtures and applied postemergence in corn. **Benefit:** Improved postemergence activity of atrazine. **Mode of Action:** Partially dissolves waxy cuticle of weeds allowing atrazine to penetrate more readily. Also reduces evaporation and aids in spreading of spray droplets on the leaf surface leading to a longer period for penetration. **Mixing:** Avoid violent agitation; partially fill sprayer, add atrazine slurry, add KORNOIL CONCENTRATE last. **Unique Characteristics:** Some injury may occur with cold, rainy weather.

## LI700

**Type of Adjuvant:** Non-ionic surfactant and pH Adjuster/Acidifier. **Chemical Composition:** Phosphatidylcholine, meth-ylacetic acid and alkyl polyoxyethylene ether 80%. **Registered Uses:** As a penetrating surfactant; as a pH adjuster/acidifier; for use with glyphosate products such as ROUNDUP, LAREDO, RENEGADE, WRANGLER and VISION. Alkaline water, even mildly alkaline, causes alkaline hydrolysis or degradation of many pesticides. Some chemicals degrade in less time than it takes to put out a tank of spray. When mixed with spray solutions, LI700 neutralizes or slightly acidifies the spray solution and prevents the breakdown hydrolysis of pH-sensitive products in the spray tank. Add LI700 before adding the pesticide. **Benefit:** Improves chemical effectiveness. **Mixing:** As a penetrating surfactant: Use 5 L of LI700/1,000 L spray mixture or 500 ml of LI700/100 L spray mixture. As a pH adjuster/acidifier: Highly alkaline water (pH 8 or higher). **Use:** 625 ml–1.25 L LI700/1,000 L water mixture.

## MERGE

**Type of Adjuvant:** Surfactant/solvent. **Chemical Composition:** 50% surfactant blend plus 50% solvent (petroleum hydrocarbons). **Registered Uses:** For use with sethoxydim. **Benefit:** Improves chemical effectiveness and provides a greater degree of consistency under varying environmental conditions. **Mode of Action:** Improves spreading of spray droplets on the leaf surface and increases contact surface area. Improves penetration of herbicide through the leaf cuticle layer. Acts as a protectant against photodegradation of sethoxydim by UV light. **Mixing:** Half-fill spray tank with water, start agitation. Add required amount of herbicide and continue agitation. Add MERGE, along with remaining water, last to the tank. Agitate thoroughly after any stoppage in spraying. **Unique Characteristics:** May cause temporary topical burn to crop plants under hot, humid weather conditions.

## MINERAL OIL (NON-HERBICIDAL)

See KORNOIL (page 187).

## MINERAL OIL/SURFACTANT (NON-HERBICIDAL)

See ASSIST OIL CONCENTRATE (page 186), CHARGE OIL CONCENTRATE in Table 7–2, *Adjuvants Used in Ontario*, on page 184, KORNOIL CONCENTRATE, left, and XA OIL CONCENTRATE (page 189).

## ON TARGET

**Type of Adjuvant:** Deposition aid/drift control agent. **Chemical Composition:** Polyvinyl Polymer (Polyacrylamide) 30%. **Registered Uses:** For use with most water soluble and wettable powder pesticides and desiccants, including glyphosate, when applied by aerial application or standard ground equipment. **Benefit:** Deposition improvement and drift retardation in spraying operations, to potentially reduce injury to adjacent crops or plants. **Mode of Action:** When tank-mixed with a pesticide, ON TARGET reduces drift by materially reducing fines resulting from shear. **Mixing:** Fill mix tank with water, pesticide and other additives and begin to agitate. Select correct dosage, SHAKE BOTTLE WELL BEFORE USING, either inject ON TARGET liquid into the suction side of the feeder or recirculating pump or slowly add ON TARGET liquid to the rapidly agitating tank mix in the area of highest turbulence by pouring a very thin stream. This obtains the best dispersion of the polymer throughout the pesticide solution. Allow mixing to continue for at least 2 minutes before spraying.

## SIDEKICK

**Type of Adjuvant:** Non-ionic liquid spreader/activator. **Chemical Composition:** Alkylarylpolyoxyethylene glycols, free fatty acids & isopropyl alcohol. **Registered Uses:** For use with imazethapyr, metsulfuron-methyl, nicosulfuron, quizalofop-ethyl. **Benefit:** Improves spray chemical effectiveness. **Mode of Action:** It is a wetting and spreading agent that improves coverage of spray mixtures. **Mixing:** Make sure the spray tank is thoroughly cleaned before mixing. Fill the spray tank half full with water. Add the required amount of herbicide as directed by its label with the agitator running. Ensure that the herbicide is completely mixed before proceeding to the next step. SLOWLY add the SIDEKICK, agitating during the entire process. Continue to agitate while filling the tank with water and agitate before and during each application to insure a uniform spray. **Unique Characteristics:** Do not exceed recommended rates of SIDEKICK, as too much may reduce the effectiveness of the herbicide due to excessive run-off. Consult product label for full directions.

## SPRAY ADJUVANT DEFOAMER

**Type of Adjuvant:** Defoamer. **Chemical Composition:** Dimethylpolysiloxane. **Registered Uses:** To reduce foaming in spray mixes of atrazine. **Benefit:** Reduces foaming. **Mixing:** To control foam when mixing spray solution, add defoamer either just before or during addition of any other spray adjuvant. To cut existing foam, add defoamer to tank and recirculate solution until foam dissipates. **Unique Characteristics:** Do not use with any other herbicide or herbicide/adjuvant mixture.

## SUPER SPREADER

**Type of Adjuvant:** Non-ionic spreader sticker surfactant. **Chemical Composition:** Octyl phenoxypoly ethoxy ethanol 50%. **Registered Uses:** For use with ALLY, AMBER, atrazine, BASAGRAN, ELIM, MUSTER, PINNACLE, TELAR, PYRAMIN FL, REFINE, REFINE EXTRA, ULTIM. **Benefit:** Improves post-emergence control of weeds that have reached their upper limit in size for susceptibility. **Mode of Action:** Causes the spray mix to form a continuous film on leaf surfaces; also makes herbicide more rainfast. **Mixing:** Use 1–2.5 L/ha. Half-fill tank with water; add herbicide with continuous agitation; complete filling of tank with water; add SUPER SPREADER STICKER with continuous agitation. **Unique Characteristics:** Higher rates are required with hard water.

## SURE-MIX

**Type of Adjuvant:** Paraffinic petroleum oil/surfactant (non-herbicidal). **Chemical Composition:** 60% Paraffinic petroleum oil plus 35.6% surfactant blend. **Registered Uses:** SURE-MIX is registered for use with ASSURE II. **Benefit:** The use of SURE-MIX results in improved activity of ASSURE II and a greater degree of consistency under varying environmental conditions. **Mode of Action:** Reduces the evaporation of spray droplets from the leaf surface and decreases the surface tension of spray droplets thus improving penetration through the cuticle of leaf surfaces. **Mixing:** Add the required amount of water to the spray tank with agitator running. Add ASSURE II and after well mixed, add 5 L of SURE-MIX for each 1,000 L of spray solution. **Unique Characteristics:** May cause some minor leaf speckling under hot and humid weather conditions.

## SURFACTANTS

See the sections AGRAL 90 (page 185), AG-SURF and CANPLUS 411 (page 186), CITOWETT PLUS (page 187), LI700, MERGE, SIDEKICK (page 188) and SUPER SPREADER, left, and the entries for COMPANION, ENHANCE and SYLGARD 309 in Table 7–2, *Adjuvants Used in Ontario*, on page 184.

## TREKKER TRAX

**Type of Adjuvant:** Foam marker. **Chemical Composition:** 24% alcohols and 30% mixed anionic and nonionic surfactants. **Benefit:** Improves placement of herbicides by indicating area of field sprayed. **Mixing:** Depending on water hardness, use 1–2 L/100–150 L water.

## UNITE

**Type of Adjuvant:** Compatibility agent. **Chemical Composition:** 83.7% acid polyglycols and methyl alcohol. **Benefit:** Improves the compatibility of liquid fertilizer-pesticide mixtures. **Mixing:** 240–1,420 mL/378.5 L. A test of physical compatibility of various pesticides and fertilizer mixtures should be performed in a small quantity to determine the exact amount of UNITE and the mixing method to be used.

## WATER CONDITIONING AGENTS

See CHOICE (page 187).

## WATER-SOLUBLE DYES

See AQUASHADE (page 186).

## XA OIL CONCENTRATE

**Type of Adjuvant:** Mineral oil/surfactant (non-herbicidal). **Chemical Composition:** 83% paraffin-base mineral oil plus 17% surfactant blend. **Registered Uses:** atrazine, ASSURE, BASAGRAN, LADDOCK. **Benefit:** May result in improved postemergence activity. **Mode of Action:** Reduces the evaporation of spray droplets from the leaf surface and decreases the surface tension of spray droplets, thus improving the penetration through the cuticle of leaf surfaces. **Unique Characteristics:** Caution with new corn varieties. Do not mix with 2,4-D; MCPA; 2,4-DB; cyanazine; MCPB or dicamba.

## Table 7–3. Herbicide Groupings for Ontario

| Group[1] | Site of Action | Single Modes of Action (alphabetic order) | Two or More Modes of Action (alphabetic order)[2] |
|---|---|---|---|
| 1 | Inhibitors of acetyl CoA carboxylase (ACCase) | Acclaim Super, Achieve, Assure, Assure II, Excel Super, Fusilade II, Hoe-grass, Poast Ultra, Select, Venture | |
| 2 | Inhibitors of acetolactate synthase (ALS) and also called acetohydroxyacid synthase (AHAS) | Accent, Arsenal, Classic, Elim EP, Muster, Pinnacle, Peak, Prism, Pursuit, Refine Extra, Reliance STS, Telar, Ultim | Broadstrike Dual Magnum (2,15), Broadstrike Treflan (2, 3), Cleansweep[3] (2, 6), Conquest[3] (2, 5), Fieldstar (2, 4), Meridian Plus[3] (2, 6), Patriot (2, 5), PeakPlus[3] (2, 4), Striker (2, 4), Ultimax[3] (2, 4), Valor (2, 3), Viper[3] (2,14) |
| 3 | Microtubule assembly inhibitors | Bonanza, Dimension, Prowl, Rival, Treflan | Broadstrike Treflan (2,3), Valor (2,3) |
| 4 | Synthetic auxins | Banvel II, Caliber, Cobutox, Compitox, Covitox Plus, Dichlorprop-D, Diphenoprop, Dycleer, Dyvel, Embutox, Estaprop, Estasol, Estamine 2,4-D, Ester, Expedite Broadleaf, Garlon, Kil-Mor, Killex, Lontrel, MCPA, Mecoprop, Savage, Mecocrop 2,4-D, Mecoturf Plus 2,4-D, Meco-D, Par III, Premium 3-Way, Release, Sword, Target, Tordon 101 mix, Tricep, Turf Herbicide, Turf-Rite 2+2, Turboprop, Weedone CB | Buctril M (4, 6), Calmix Pellets (4, 5), Distinct (4, 19), Fieldstar (2, 4), Marksman (4, 5), PeakPlus[3] (2, 4), Shotgun (4, 5), Stampede CM (4, 7), Striker (2, 4), Ultimax[3] (2, 4) |
| 5 | Inhibitors of photosynthesis at photosystem II, Site A | Aatrex, Atrazine, Bladex, Gesagard, Hyvar X, Lexone, Princep, Pronone, Pyramin FL, Sencor, Simadex, Simazine, Sinbar, Velpar | Axiom (5, 15), Calmix Pellets (4, 5), Conquest[3] (2, 5), Converge (5, 28), Krovar (5, 7), Laddok (5, 6), Marksman (4, 5), Patriot (2, 5), Primextra II Magnum (5, 15), Shotgun (4, 5) |
| 6 | Inhibitors of photosynthesis at photosystem II, Site A | Basagran, Basagran Forte, Lentagran, Pardner | Buctril M (4, 6), Cleansweep[3] (2, 6), Laddok (5, 6), Meridian Plus[3] (2, 6) |
| 7 | Inhibitors of photosynthesis at photosystem II, Site B | Afesin, Afolan, Betamix, Betanex, Herbec, Karmex, Linuron, Lorox, Patoran, Spin-Aid | Krovar (5, 7), Stampede CM (4, 7) |
| 8 | Conjugation of acetyl co-enyme A | Avadex, Avenge, Betasan, Eradicane, Eptam, Ro-Neet | |
| 9 | Inhibitors of 5-enolpyruvylshikimimate-3-phosphate synthase (EPSP) | Clear-It, Credit, Expedite Grass & Weed, EZJect, Glyfos, Laredo, Renegade, Roundup, Touchdown, Vantage, Vision, Wrangler | Roundup Fast Forward (9, 10) |
| 10 | Inhibitors of glutamine synthetase | Liberty, Ignite | Roundup Fast Forward (9, 10) |
| 11 | Inhibitors of carotenoid biosynthesis | Amitrol, Amitrol-T | |
| 14 | Inhibitors of protoporphyrinogen oxidase (Protox) | Blazer, Goal, Reflex, Ronstar | Viper[3] (2, 14) |
| 15 | Conjugation of acetyl co-enyme A | Devrinol, Dual Magnum, Dual II Magnum, Frontier | Axiom (5, 15), Broadstrike Dual Magnum (2, 15), Primextra II Magnum (5, 15) |
| 19 | Inhibitors of auxin transport system | Alanap | Distinct (4, 19) |
| 20 | Inhibits cell wall synthesis, Site A | Casoron | |
| 22 | Photo system I - electron diverters | Gramoxone, Reglone, Reward, Weed & Grass Killer | |
| 23 | Inhibitors of mitosis | CIPC | |
| 27 | Others | Basamid, Krenite, Vapam | |
| 28 | Inhibitors of p-hydroxyphenyl pyruvate dioxygenase (HPPD) | | Converge (5, 28) |

---

[1] Herbicide groupings for Ontario follow the Weed Science Society of America's nationally accepted grouping. Groups 12, 13, 16, 17, 18, 21, 24, 25 and 26 are not available in Ontario.

[2] Products with two or more sites of action are followed by the group numbers involved.

[3] Indicated herbicides sold as a co-pack under this trade name.

## Table 7–4.

## Interval Before Rainfall (Postemergence)

Rainfall shortly after application of a postemergent herbicide may reduce weed control. This effect will vary with the product, the formulation, the interval of time and the drying conditions between application and rainfall, as well as with the amount, intensity and duration of rainfall. The following information is based on label information and additional detail supplied by the chemical industry. **For further information, contact the manufacturer.** In the case of a tank mix, use the longest time interval of the products being considered.

| 0 to 15 Minutes | 1 Hour | 2 Hours | 3 Hours | 4 Hours | 6 Hours | 8 Hours |
|---|---|---|---|---|---|---|
| GRAMOXONE | ASSURE II | ACCENT | GOAL 2XL | 2,4-D amine | AMITROL 240 | AFOLAN F |
| REGLONE DESICCANT | EXCEL SUPER | atrazine | | IGNITE | BASAGRAN | LINURON 480 |
| REWARD | HOE-GRASS | BLADEX | | LONTREL | BETAMIX | LOROX |
| | KORIL | FUSILADE II | | PINNACLE | BETANEX | |
| | PARDNER | LENTAGRAN | | REFLEX | BLAZER | |
| | POAST ULTRA | PRISM | | ROUNDUP TRANSORB | CREDIT | |
| | SELECT | PURSUIT | | TROPOTOX PLUS | GLYFOS | |
| | | VENTURE | | UPBEET | LADDOK | |
| | | | | VANTAGE PLUS | LEXONE | |
| | | | | | PYRAMIN FL | |
| | | | | | ROUNDUP | |
| | | | | | SENCOR | |
| | | | | | SPIN-AID | |
| | | | | | TOUCHDOWN | |
| | | | | | VANTAGE | |

## Table 7–5. Herbicide Crop Rotation and Soil pH Restrictions – Horticultural Crops

(For other crops, consult the label.)

| Trade Name | Asparagus | Beans, Lima | Beans, Snap | Beets, Red | Broccoli | Brussels Sprouts | Cabbage | Carrots | Cauliflower | Celery | Corn, Sweet | Cucumber | Garlic | Herbs | Lettuce | Muskmelons | Onions | Parsnips | Peas | Peppers | Potatoes | Pumpkins | Rutabaga | Spinach | Squash | Sugarbeets | Tomatoes (Transplanted) | Watermelons |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Months Between Application and Planting | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ACCENT | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| ATRAZINE <1.0 kg ai/ha | 22 | 10 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | — | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 10 | 22 | 10 | 22 | 22 | 22 | 22 | 22 | 10 | 22 |
| ATRAZINE >1.0—1.5 kg ai/ha | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | — | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| AXIOM | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | 10 | f | f | f | f | f | 10 | f |
| BROADSTRIKE DUAL MAGNUM, BROADSTRIKE TREFLAN (Soil pH >7.8 and OM <2%) | f | 10 | 10 | f | f | f | f | f | f | f | 22 | 22 | f | f | f | f | f | f | 10 | 22 | 22 | f | f | f | f | f | 26 | f |
| CLASSIC (Soil pH 7.4 and less) | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| CLASSIC (Soil pH 7.4 to 7.8) | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| CLEAN SWEEP[1] | 22 | 22 | 22 | f | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | — | 22 | 22 | 22 | 22 | 22 | 22 | f | 22 | 22 |
| CONQUEST[1] | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| CONVERGE | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | 10 | f | f | f | f | f | f | f |
| ELIM EP, PRISM | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | — | f | f | f | f | f | — | f |
| FIELDSTAR (Soil pH <5.9 or >7.8) | f | 10 | 10 | f | f | f | f | f | f | f | 22 | 22 | f | f | f | f | f | f | 10 | f | 26 | f | f | f | f | f | 26 | f |
| FIRSTRATE | f | f | 9 | 9 | f | f | f | f | f | f | 18 | f | f | f | f | f | f | f | 9 | f | f | f | f | f | f | f | f | f |
| LEXONE, SENCOR (Soil pH >7.5) | — | 10 | 10 | 22 | 22 | 22 | 22 | 10 | 22 | 22 | 10 | 22 | 10 | 10 | 22 | 22 | 22 | 10 | 10 | 22 | — | 22 | 22 | 22 | 22 | 22 | — | 22 |
| LONTREL | 22 | 22 | 22 | 22 | 22 | 22 | — | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | — | 22 | 22 | — | 22 | 22 |
| MERIDIAN PLUS[1] | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | 9 | f |
| MUSTER | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| PATRIOT | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| PEAK, PEAK PLUS[1] | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | 10 | f | f | f | f | f | f | f | f | f |
| PURSUIT | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | — | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| REFLEX | f | f | — | 18 | 18 | 18 | 18 | f | 18 | f | 18 | f | f | f | f | f | f | f | f | f | f | f | 18 | f | f | 18 | f | f |
| RELIANCE STS (Soil pH 7.4 and less) | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| RELIANCE STS (Soil pH 7.4 to 7.8) | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| SIMAZINE/PRINCEP <2 kg ai/ha | 22 | 22 | 22 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| SIMAZINE/PRINCEP >2 kg ai/ha | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| STRIKER | f | 10 | 10 | f | f | f | f | f | f | f | 22 | 22 | f | f | f | f | f | f | 10 | f | 26 | f | f | f | f | f | 26 | f |
| SUMMIT | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| ULTIM | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| ULTIMAX[1] | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f |
| VALOR | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| VIPER[1] | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | f | 10 | f |

— = Registered for use; f = Field bioassay; user assumes liability for all crops not indicated on the label.

---

[1] Herbicides sold as a co-pack under this trade name.

## Table 7–6. Herbicide Crop Rotation and Soil pH Restrictions – Field Crops

(For other crops, consult the label.)

| TRADE NAME | Alfalfa | Barley | Barley (Underseeded) | Beans, Kidney | Beans, White | Canola I ncluding Rr | Canola, IMI Smart | Clover, Red | Corn, Field, Including RR, LL, PP | Corn, Clearfield | Corn, Seed | Flax-linseed | Oats | Oats (Underseeded) | Peanuts | Rye, Fall | Rye, Fall (Underseeded) | Soybeans | Sunflowers | Tobacco | Wheat, Spring | Wheat, Spring (Underseeded) | Wheat, Winter | Wheat, Winter , (Underseeded |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Months Between Application and Planting | | | | | | | | | | | | | | | | | | | | | | | |
| ACCENT | 10 | 10 | 10 | f | 10 | 10 | 10 | 10 | – | – | f | f | f | f | f | f | f | 10 | f | f | f | f | 4 | 4 |
| ATRAZINE <1.0 kg ai/ha | 10 | 10 | 10 | 10 | 10 | 22 | 22 | 10 | – | – | – | 10 | 10 | 10 | 22 | 10 | 10 | 10 | 22 | 22 | 10 | 10 | 4 | 10 |
| ATRAZINE >1.0–1.5 kg ai/ha | 22 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | – | – | – | 10 | 22 | 22 | 22 | 10 | 22 | 10 | 22 | 22 | 10 | 22 | 10 | 22 |
| AXIOM | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | – | – | 10 | 10 | 10 | 10 | 10 | f | f | – | 10 | 10 | 10 | 10 | 4 | 4 |
| BROADSTRIKE DUAL MAGNUM,<br>BROADSTRIKE TREFLAN (Soil pH >7.8 and OM <2%) | 10 | 10 | f | 10 | 10 | 26 | 26 | 10 | 10 | 10 | 10 | f | 10 | f | f | f | f | – | f | f | 10 | f | 4 | f |
| CLASSIC (Soil pH 7.4 and less) | 10 | 10 | f | f | 10 | f | f | f | 10 | 10 | f | f | f | f | f | f | f | 10 | f | f | f | f | 3 | f |
| CLASSIC (Soil pH 7.4 to 7.8) | 22 | 22 | f | f | 10 | f | f | f | 22 | 22 | f | f | f | f | f | f | f | 10 | f | f | f | f | 3 | f |
| CLEAN SWEEP[1] | 22 | 9 | 22 | 22 | 22 | 22 | 9 | 22 | 9 | 9 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | – | 22 | 22 | 9 | 22 | 3.3 | 22 |
| CONQUEST[1] | 22 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | 10 | 10 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | – | 22 | 22 | 10 | 22 | 4 | 22 |
| CONVERGE | 10 | 10 | f | f | f | 22 | 22 | f | – | – | 10 | f | 10 | f | f | f | f | 10 | f | f | 10 | f | 4 | f |
| ELIM EP, PRISM | f | 10 | 10 | f | 10 | 10 | 10 | 10 | – | – | f | f | f | f | f | f | f | 10 | f | f | f | f | 4 | 4 |
| FIELDSTAR (Soil pH <5.9 or >7.8) | 10 | 10 | f | 10 | 10 | 26 | 26 | 10 | – | – | 10 | f | 10 | f | f | f | f | 10 | f | f | 10 | f | 4 | f |
| LEXONE, SENCOR (Soil pH >7.5) | 10 | 10 | 10 | 10 | 10 | 22 | 22 | 10 | – | – | 10 | 10 | 10 | 10 | 10 | 10 | 10 | – | 10 | 22 | 10 | 10 | 3.3 | 10 |
| LONTREL | 22 | 10 | 22 | 22 | 22 | – | – | 22 | 22 | 22 | 22 | 10 | 10 | 22 | 22 | 10 | 22 | 22 | 22 | 22 | 10 | 22 | 10 | 22 |
| MERIDIAN PLUS[1] | f | 9 | f | 9 | 9 | 22 | 9 | f | 9 | 9 | 22 | f | 9 | f | f | f | f | – | f | f | f | f | 4 | f |
| MUSTER | f | 10 | f | f | f | – | – | f | f | f | f | f | 10 | f | f | f | f | 10 | f | f | 10 | f | 4 | f |
| PATRIOT | 22 | 10 | 22 | 10 | 10 | 22 | 22 | 22 | 10 | – | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 10 | 22 | 4 | 22 |
| PEAK, PEAK PLUS[1] | 22 | 10 | f | f | 10 | f | f | f | – | – | f | f | 10 | f | f | f | f | 10 | f | f | f | f | f | f |
| PURSUIT | – | 10 | 22 | – | – | 22 | – | 22 | 10 | – | 22 | 22 | 22 | 22 | 22 | 22 | 22 | – | 22 | 22 | 10 | 22 | 3.3 | 22 |
| REFLEX | f | f | f | – | – | 18 | 18 | f | 10 | 10 | f | f | f | f | f | f | f | – | f | f | 10 | f | 4 | f |
| RELIANCE STS (Soil pH 7.4 and less) | 10 | f | f | f | 10 | f | f | f | 10 | 10 | f | f | f | f | f | f | f | 10 | f | f | f | f | 3 | f |
| RELIANCE STS (Soil pH 7.4 to 7.8) | 22 | 22 | f | f | 10 | f | f | f | 22 | 22 | f | f | f | f | f | f | f | 10 | f | f | f | f | 3 | f |
| SIMAZINE/PRINCEP <2 kg ai/ha | – | 10 | 10 | 22 | 22 | 22 | 22 | 22 | – | – | 10 | 22 | 10 | 10 | 10 | 10 | 10 | 22 | 22 | 22 | 10 | 10 | 10 | 10 |
| SIMAZINE/PRINCEP >2 kg ai/ha | – | 22 | 22 | 22 | 22 | 22 | 22 | 22 | – | – | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| STRIKER | 10 | 10 | f | 10 | 10 | 26 | 26 | 10 | – | – | 10 | f | 10 | f | f | f | f | 10 | f | f | 10 | f | 4 | f |
| ULTIM | f | 10 | 10 | f | 10 | 10 | 10 | 10 | – | – | f | f | f | f | f | f | f | 10 | f | f | f | f | 4 | 4 |
| ULTIMAX[1] | f | 10 | f | f | f | f | f | f | – | – | f | f | f | f | f | f | f | 10 | f | f | f | f | 4 | f |
| VALOR | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 10 | 10 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | – | 18 | 18 | 18 | 18 | 18 | 18 |
| VIPER[1] | f | f | f | f | f | f | f | f | 10 | 10 | f | f | f | f | f | f | f | – | f | f | f | f | 4 | f |

– = Registered for use; f = Field bioassay; user assumes liability for all crops not indicated on the label.

---

[1] Herbicides sold as a co-pack under this trade name.

## Special Methods of Weed Control

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Preplant-Site Preparation Prior to Any Crop** | | | |
| amitrole<br>AMITROL 240 (231 g/L) | 1 to 2 kg/ha<br>4.2 to 8.4 L/ha | 1.68 to 3.36 L/ac | For dandelions and annual weeds.<br>For corn, soybeans, white beans, wheat, barley, canola and field peas.<br>Apply in 100 to 200 L/ha water (40 to 180 L/ac) 10 to 14 days before planting the crop.<br>Wait 10 to 14 days before tillage and planting (**ONLY** soybeans may be planted 6 days after application when applied at the low rate).<br>Use additional herbicide treatments to control weed species that emerge after application.<br>May be tank-mixed with ROUNDUP or PURSUIT where registered. |
| amitrole<br>AMITROL 240 (231 g/L) | 3 to 4 kg/ha<br>12.5 to 16.5 L/ha | 5 to 6.6 L/ac | For quackgrass, Canada thistle, sow thistle (fall treatment) and annual weeds.<br>For use **ONLY** before white beans, corn and soybeans.<br>Apply in 100 to 200 L/ha water (40 to 180 L/ac).<br>Apply to actively growing weeds up to 10 cm tall in the fall (until heavy frost) or in spring.<br>Plow or thoroughly disk 10 to 14 days after application.<br>Cultivation may be required when the crop is emerged to improve weed control. |
| glyphosate*<br>glyphosate (360 g/L)<br>* Various formulations are available, see Appendix A, on page 271. See label for specific uses and rates. | 0.27 to 4.32 kg/ha<br>0.75 to 12 L/ha | 0.3 to 4.8 L/ac | For actively growing weeds in the fall or spring prior to emergence of any crop.<br>Allow 5 to 7 days translocation time after application before doing any tillage when conditions are good. If cool temperatures follow application, allow additional time for translocation to be completed before disturbing treated weeds.<br>Only weeds emerged at application time will be controlled. Additional weed control programs will be necessary to control weeds germinating later.<br>Repeat application to regrowth may be necessary for complete control.<br>For **annual weeds**, use 0.75 to 3.5 L product/ha (0.3 to 1.4 L/ac).<br>Use 50 to 100 L/ha water (20 to 40 L/ac) for the low rate, or use a surfactant with larger water volumes.<br>Water volumes of 100 to 300 L/ha water (40 to 120 L/ac) can be used with the 3.5 L rate.<br>For **dandelions and quackgrass**, use 2.5 to 7 L product/ha (1 to 2.8 L/ac).<br>Apply when plants have at least 3 to 4 new leaves.<br>The low rate (2.5 L/ha (1 L/ac)) will provide a minimum of one season control while higher rates (4.75 to 7 L/ha (1.9 to 2.8 L/ac)) will provide longer term control.<br>For dandelion control, apply 2.5 L/ha (1 L/ac) if 15 cm or less in diameter and 3.5 to 5 L/ha (1.4 to 2 L/ac) if larger than 15 cm.<br>For **perennial broadleaf weeds**, use 7 to 12 L product/ha (2.8 to 4.8 L/ac)<br>Canada thistle and sow-thistle should be at least in early bud, milkweed at bud, bindweed at full flower, and dogbane past full bloom for best results.<br>For undisturbed perennials such as sod in non-crop areas, use the highest rate and repeat it when plants regrow to optimum stage. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| glyphosate/glufosinate ammonium<br>ROUNDUP FASTFORWARD PRESEED ((30:1) 310 g/L) | 0.465 to 2.604 kg/ha<br>1.5 to 8.4 L/ha | 0.6 to 3.4 L/ac | For annual grasses up to 15 cm tall, use 0.6 L/ac.<br>For annual grass and broadleaf weeds up to 15 cm tall, use 1.1 L/ac.<br>For annual weeds over 15 cm tall, use 1.7 L/ac.<br>For quackgrass, use 1.5 L/ac.<br>For dandelions less than 15 cm, use 2 L/ac.<br>For heavier infestations and for dandelions larger than 15 cm, use 3.4 L/ac. |
| paraquat<br>GRAMOXONE (200 g/L) | 0.55 to 1.1 kg/ha<br>2.75 to 5.5 L/ha | 1.1 to 2.2 L/ac | Apply to actively growing vegetation at least 3 days prior to crop emergence.<br>Use the high rate when weeds are above 5 cm in height.<br>Apply in 300 to 1,100 L/ha water (120 to 440 L/ac).<br>Complete coverage is important. Use higher water volumes on dense vegetation.<br>Perennial weeds will only be suppressed.<br>Only emerged weeds will be controlled. |

## Stale Seedbed and Inter-Row Weeding

The stale seedbed technique is useful when the soil can be worked well before planting, and weeds are allowed to emerge for several weeks. Apply one of the non-selective postemergent herbicides listed here to kill emerged weeds. Seeding or planting directly into the killed weeds with minimal soil disturbance will allow the crop to establish before the next flush of weed emergence. Follow up with either cultivation, hoeing or postemergent or directed herbicides to control later germinating weeds. Where registered, some herbicides can be applied after seeding but before crop emergence.

| | | | |
|---|---|---|---|
| glufosinate ammonium<br>IGNITE (150 g/L) | 0.405 to 0.75 kg/ha<br>2.7 to 5 L/ha | 1.08 to 2 L/ac | For use **ONLY** in carrot, lettuce and onion crops.<br>Apply in a minimum of 110 to 330 L/ha (44 to 132 L/ac) of water.<br>Apply after seeding, but prior to emergence of the crop. |
| glyphosate*<br>glyphosate (360 g/L)<br><br>* Various formulations are available, see Appendix A, on page 271. See label for specific uses and rates. | 0.27 to 1.26 kg/ha<br>0.75 to 3.5 L/ha | 0.3 to 1.4 L/ac | Till and fertilize soil in early spring.<br>Allow weeds to grow, and spray weeds just before seeding crop.<br>Use low rate for small weeds (8 cm), medium rates for weeds 8 to 15 cm and higher rate for weeds over 15 cm tall.<br>Apply recommended herbicides to control new flushes of weeds or use mechanical means of control. |
| glyphosate/glufosinate ammonium<br>ROUNDUP FASTFORWARD PRESEED ((30:1) 310 g/L) | 0.465 to 2.604 kg/ha<br>1.5 to 8.4 L/ha | 0.6 to 3.4 L/ac | For annual grasses up to 15 cm tall, use 0.6 L/ac.<br>For annual grass and broadleaf weeds up to 15 cm tall, use 1.1 L/ac.<br>For annual weeds over 15 cm tall, use 1.7 L/ac.<br>For quackgrass, use 1.5 L/ac.<br>For dandelions less than 15 cm, use 2 L/ac.<br>For heavier infestations and for dandelions larger than 15 cm, use 3.4 L/ac. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| paraquat | 0.6 to 1.1 kg/ha | | For emerged weeds after the crop seed is sown, but before crop emergence. |
| GRAMOXONE (200 g/L) | 3 to 5.5 L/ha | 1.2 to 2.2 L/ac | For use **ONLY** in beans (all types), beets, carrots, cole crops, corn, onions, peas, cucumbers, potatoes, soybeans and turnips. |
| or diquat | 0.6 to 1.1 kg/ha | | |
| REGLONE (200 g/L) | 3 to 5.5 L/ha | 1.2 to 2.2 L/ac | In inter-row weeding, special low pressure equipment is used to apply the herbicide on emerged weeds without contact with leaves of the crop plants.<br>For small areas, apply 30 mL product in 10 L water per 100 $m^2$. |
| paraquat/diquat<br>C.I.L.WEED & GRASS<br>KILLER WEED-BAN | See label | | **Domestic** — Soluble granular formulations for home garden use. Check label for rates. |
| **Post-Harvest (Broadleaf Herbicides)** | | | |
| 2,4-D | 0.85 to 1.555 kg/ha | | Apply in the fall at the time of rapid growth. |
| ESTASOL (564 g/L) | 1.5 to 2.75 L/ha | 0.6 to 1.1 L/ac | Use the higher rate for legumes and perennial weeds. |
| ESTER 600 (564 g/L) | 1.5 to 2.75 L/ha | 0.6 to 1.1 L/ac | For best results, apply to actively growing vegetation at least 2 weeks before a killing frost. |
| ESTER 700 (660 g/L) | 1.29 to 2.36 L/ha | 0.52 to 0.94 L/ac | **Do NOT** apply before fall wheat or barley. |
| 2,4-D/ dicamba/ mecoprop | 0.534 to 0.849 kg/ha | | Ground application **ONLY**. |
| KIL-MOR (485 g/L) | 1.1 to 1.75 L/ha | 0.44 to 0.7 L/ac | **Do NOT** apply if wind velocity exceeds 8 km/h.<br>Apply in 200 L/ha water (80 L/ac). |
| dicamba | 1.2 kg/ha | | Apply in the fall to actively growing vegetation at least 2 weeks prior to a killing frost. |
| BANVEL II (480 g/L) | 2.5 L/ha | 1 L/ac | **Do NOT** apply before fall-seeded crops.<br>**ONLY** cereals, soybeans, field corn, sweet corn or white beans may be grown the year after application. |
| **Post-Harvest (Grass and Broadleaf Herbicides)** | | | |
| amitrole | 3 to 4 kg/ha | | Apply after harvest when regrowth is 10 to 15 cm tall for Canada thistle and sow-thistle. |
| AMITROL 240 (231 g/L) | 12.5 to 16.5 L/ha | 5 to 6.6 L/ac | **Do NOT** cultivate for 2 weeks after application.<br>**Do NOT** apply after a heavy frost, generally after Oct. 1.<br>**Do NOT** plant to a crop for 8 months after treatment. |
| dicamba | 0.6 kg/ha | | Apply in the fall to actively growing vegetation at least 2 weeks prior to a killing frost. |
| BANVEL II (480 g/L) | 1.25 L/ha | 0.5 L/ac | **Do NOT** apply before fall-seeded crops. |
| plus glyphosate | 0.6 kg/ha | | |
| ROUNDUP (356 g/L) | 1.7 L/ha | 0.68 L/ac | |
| plus non-ionic surfactant | 0.35 L/ha | 0.14 L/ac | |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| glyphosate*<br>glyphosate (360 g/L)<br><br>* Various formulations are available, see Appendix A, on page 271. See label for specific uses and rates. | 0.27 to 4.32 kg/ha<br>0.75 to 12 L/ha | 0.3 to 4.8 L/ac | For actively growing weeds in the fall or spring prior to emergence of any crop.<br>Allow 5 to 7 days translocation time after application before doing any tillage when conditions are good. If cool temperatures follow application, allow additional time for translocation to be completed before disturbing treated weeds.<br>Only weeds emerged at application time will be controlled. Additional weed control programs will be necessary to control weeds germinating later.<br>Repeat application to regrowth may be necessary for complete control.<br>For **annual weeds**, use 0.75 to 3.5 L product/ha (0.3 to 1.4 L/ac).<br>Use 50 to 100 L/ha water (20 to 40 L/ac) for the low rate, or use a surfactant with larger water volumes.<br>Water volumes of 100 to 300 L/ha water (40 to 120 L/ac) can be used with the 3.5 L rate.<br>For **dandelions and quackgrass**, use 2.5 to 7 L product/ha (1 to 2.8 L/ac).<br>Apply when plants have at least 3 to 4 new leaves.<br>The low rate (2.5 L/ha (1 L/ac)) will provide a minimum of one season control while higher rates (4.75 to 7 L/ha (1.9 to 2.8 L/ac)) will provide longer term control.<br>For dandelion control, apply 2.5 L/ha (1 L/ac) if 15 cm or less in diameter and 3.5 to 5 L/ha (1.4 to 2 L/ac) if larger than 15 cm.<br>For **perennial broadleaf weeds**, use 7 to 12 L product/ha (2.8 to 4.8 L/ac).<br>Canada thistle and sow-thistle should be at least in early bud, milkweed at bud, bindweed at full flower, and dogbane past full bloom for best results.<br>For undisturbed perennials such as sod in non-crop areas, use the highest rate and repeat it when plants regrow to optimum stage. |

## Spot Treatment With Handheld Equipment for Selective Weed Control

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| amitrole<br>AMITROL 240 (231 g/L) | 3 to 4 kg/ha<br>12.5 to 16.5 L/ha | 5 to 6.6 L/ac | Use **ONLY** for non-crop land and pasture.<br>Thoroughly wet all leaves and stems of weeds. Repeat applications when new growth appears.<br>Apply to Canada thistle and sow-thistle at early bud to bloom, quackgrass and horsetail at 10 to 15 cm, dandelion when young, toadflax and hoary cress at advanced rosette, milkweed in early summer, poison ivy when fully leafed.<br>**Do NOT** allow livestock to eat treated vegetation. Keep livestock off treated area until weeds are dead and new growth has emerged. |
| glyphosate<br>EXPEDITE GRASS & WEED (147 g/L) | 0.88 to 4.265 kg/ha<br>6 to 29 L/ha | 2.4 to 11.6 L/ac | EXPEDITE herbicides are ready-to-use products that must be applied with the EXPEDITE application system.<br>This low volume application should not be applied "spray to wet" or run-off.<br>Material should be calibrated for proper use rate prior to application. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| glyphosate*<br>glyphosate (360 g/L)<br><br>* Various formulations are available, see Appendix A, on page 271. See label for specific uses and rates. | 0.36 kg to 0.72/100 L<br>1 L to 2 L/100 L | | For actively growing weeds. Direct spray to avoid desirable vegetation.<br>Allow 5 to 7 days translocation time after application before doing any mowing or tillage when conditions are good. If cool temperatures follow application, allow additional time for translocation to be completed before disturbing treated weeds.<br>Canada thistle and sow-thistle should be at least in early bud, milkweed at bud, bindweed at full flower, and dogbane past full bloom, and quackgrass with 3 to 4 new leaves for best results. |

## Wick Wiper and Roller Application

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| glyphosate*<br>glyphosate (360 g/L)<br><br>* Various formulations are available, see Appendix A, on page 271. See label for specific uses and rates. | 0.36 kg/2 L water<br>1 L/2 L water | | For use on soybeans, white beans, apple, cherry, peach, pear, plum, grape, strawberries and cranberries.<br>Apply to weeds that extend above the crop sufficiently to allow good contact with the application equipment.<br>**Do NOT** contact the crop with the equipment or allow the chemical solution to drip from the applicator on to the crop.<br>A 33% herbicide mixture (1 L/2 L of water) provides good control of most weeds. |

## Seedbeds and Potting Soil: Soil-Applied Fumigants

**To convert kg/ha or L/ha to g/ha or mL/100 m$^2$:** Multiply by 10 and change units to 100 m$^2$.

**Example:** 11 kg/ha becomes 110 g/100 m$^2$
28.4 L/ha becomes 284 mL/100 m$^2$

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| dazomet<br>BASAMID (98 Gr) | 500 kg/ha<br>510 kg/ha | 204 kg/ac | **Do NOT** use below 6°C.<br>Refer to manufacturer's directions for specific details as well as directions on sealing soil, evacuating gases and performing the safety germination test. |
| metam sodium<br>VAPAM (380 g/L) | 3.8 kg/100 m$^2$<br>10 L/100 m$^2$<br>in 800 L water | | Apply as a drench to a soil that should be wet to a depth of at least 8 cm.<br>**Do NOT** plant for 10 to 14 days or longer if the weather is cool. |
| methyl bromide/ chloropicrin<br>TERR-O-GAS 67 (67 Li) | | | A poisonous gas that must be applied under a gas-proof cover (usually plastic).<br>Its use is subject to the *Pesticides Act*.<br>It may be used by the growers on their own seedbeds but they must obtain a permit from the Ontario Ministry of the Environment and Energy each time it is used.<br>The manufacturer's instructions must be followed, and the seedbed or greenhouse aired thoroughly after the treatment period.<br>If there is any question, the safety precautions in the *Pesticides Act* should be studied, or inquiry made at the resource centres of the Ontario Ministry of Agriculture and Food or the Ontario Ministry of the Environment and Energy. |

## Table 7–7.
## Non-Selective Herbicides Available for Preplant Site Preparation

| Crop | AMITROL 240 | BASAMID | GRAMOXONE | IGNITE | REGLONE | CREDIT, GLYFOS, ROUNDUP, TOUCHDOWN, VANTAGE | VAPAM |
|---|---|---|---|---|---|---|---|
| **Vegetables** | | | | | | | |
| Field vegetable seedbeds | | X | | | | X | X |
| Stale seedbeds | | | X | | | X | |
| Asparagus | | | | X | | X | |
| Beans | | | | | X | X | |
| Beets | | | | X | X | X | |
| Carrots | | | | X | X | X | |
| Celery | | | | | | X | |
| Cole Crops | | | | | X | X | |
| Corn | | | | | X | X | |
| Cucumbers | | | | | X | X | |
| Eggplant | | X | | | | X | |
| Ginseng | | | | | | X | |
| Lettuce | | X | | X | | X | |
| Melons | | | | | | X | |
| Onions | | | | X | X | X | |
| Peas | | | | | X | X | |
| Peppers | | X | | | | X | |
| Potatoes | | | | | X | X | |
| Rutabagas | | | | | X | X | |
| Squash | | | | | | X | |
| Tomatoes | | X | | | | X | |

## Table 7–8.

## Preplant Herbicide Weed Control Ratings

***Notes:*** Weed control ratings are given as 0–9 where 0 indicates no control and 9 indicates 90%–100% control under ideal conditions.
Ratings are subjective values based on best available information and give general comparisons based on use as described in this publication.
Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated.
Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.
Ratings in BOLD indicate the weed is listed on the product label for control or suppression.
Please see product label for more information on registered weed species, product uses and precautions.

| | **Annuals** | | **Perennials** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trade Name** | **Annual Grasses** | **Annual Broadleaves** | **Bindweed, Field** | **Chickweed, Mouse-Eared** | **Dandelion** | **Golden-Rod** | **Ground-Ivy (Creeping Charlie)** | **Horsetail** | **Mallow** | **Milkweed** | **Nut Sedge** | **Plantains** | **Poison Ivy** | **Quackgrass** | **Sow-Thistle** | **Thistle, Canada** | **Vetches** |
| **Preplant Herbicides** | | | | | | | | | | | | | | | | | |
| AMITROL 240 | ** | ** | —[1] | ? | **9** | —[1] | ? | 7 | ? | —[1] | —[1] | 8 | 8 | **7** | —[1] | **7** | ? |
| CREDIT, GLYPHOS, ROUNDUP, TOUCHDOWN, VANTAGE | ** | ** | **7**[1] | **9** | **7/8**[2] | ? | 5 | 0 | 5 | —[1] | **7** | **9** | **8** | **8/9** | —[1] | **7**[1] | 5 |
| IGNITE | ** | ** | 8[3] | ? | **8** | ? | ? | 7[3] | ? | 6[3] | 7[3] | ? | ? | 8[3] | 8[3] | 8[3] | ? |
| GRAMOXONE | ** | ** | —[4] | —[4] | —[4] | ? | —[4] | —[4] | —[4] | —[4] | 0 | —[4] | —[4] | **5** | —[4] | 0 | —[4] |

** = Indicates that most annual weeds will be controlled if emerged; ? = Insufficient information available to make a rating.

---

[1] Optimum growth stages for best control of these weeds will not likely be attained prior to planting in early to mid-spring.

[2] Use higher rates for plants over 15 cm tall or across.

[3] Repeated applications may be necessary.

[4] Top growth only, regrowth can be expected.

# ASPARAGUS

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

## Before Emergence of Direct-Seeded Asparagus — Postemergence Grass and Broadleaf Herbicides

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| glufosinate ammonium<br>IGNITE (150 g/L) | 0.405 to 0.75 kg/ha<br>2.7 to 5 L/ha | 1.08 to 2 L/ac | Apply in 110 to 330 L/ha (44 to 132 L/ac) water.<br>Spray uniformly on emerged weeds prior to emergence of the crop.<br>Weeds that have not emerged will not be controlled. |
| paraquat<br>GRAMOXONE (200 g/L) | 0.6 to 1.1 kg/ha<br>3 to 5.5 L/ha | 1.2 to 2.2 L/ac | Apply in 300 to 1,100 L/ha (120 to 440 L/ac) water.<br>Spray GRAMOXONE as a "chemical mower" to kill emerged seedling weeds before the first asparagus seedlings are beginning to emerge. |
| followed by napropamide<br>DEVRINOL DF (50 DF) | 2.25 to 4.5 kg/ha<br>4.5 to 9 kg/ha | 1.8 to 3.6 kg/ac | Apply DEVRINOL as a separate application just before a second flush of weeds emerge. |
| terbacil<br>SINBAR (80 WP) | 0.3 kg/ha<br>0.38 kg/ha | 0.15 kg/ac | PRE – Apply as a broadcast treatment within 2 days of seeding.<br>Plant asparagus seed to a depth of 4 cm in coarse (sandy) soils or 2.5 cm deep in fine (clay) soils into newly cultivated fields. |

## Direct-Seeded Asparagus — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.075 to 0.25 kg/ha<br>0.6 to 2 L/ha | 0.24 to 0.8 L/ac | Apply to actively growing grasses prior to tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails).<br>Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly.<br>Thorough preplant tillage, fragmenting quackgrass rhizomes improves control.<br>**Do NOT** cultivate between rows until 5 days after application. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For volunteer grains, use 0.47 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 40 days. |
| **1st Year Crown-Established Asparagus — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| napropamide<br>DEVRINOL DF (50 DF) | 2.25 to 4.5 kg/ha<br>4.5 to 9 kg/ha | <br>1.8 to 3.6 kg/ac | PPI – Incorporation by irrigation or rainfall is essential.<br>Treat at planting time or soon after planting before weed seedlings appear.<br>Use lower rate on sandy soils and the higher rate on clay soils. |
| **1st Year Crown-Established Asparagus — Postemergence Grass Herbicides** | | | |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.075 to 0.25 kg/ha<br>0.6 to 2 L/ha | <br>0.24 to 0.8 L/ac | Apply to actively growing grasses prior to tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails).<br>Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass & wirestem muhly.<br>Thorough preplant tillage, fragmenting quackgrass rhizomes improves control.<br>**Do NOT** cultivate between rows until 5 days after application. |

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For annual grass, use 0.32 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| plus surfactant/solvent | | | For volunteer grains, use 0.47 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. |
| | | | Use 100 to 200 L water/ha (40 to 80 L water/ac). |
| | | | Grasses emerging after application will not be controlled. |
| | | | Spray tips angled forward 45° will give better coverage. |
| | | | **Do NOT** use flood jet or hollow cone nozzles. |
| | | | **Do NOT** apply if rain is expected within 1 hour after application. |
| | | | Preharvest interval is 40 days. |
| **2nd Year and Established Asparagus — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| diuron | 1.75 to 2.25 kg/ha | | PRE – Disk before any shoots appear in the spring on established plantings. |
| KARMEX (80 DF) | 2.19 to 2.81 kg/ha | 0.88 to 1.12 kg/ac | A second application may be made after the post-harvest disking. |
| | | | Use lower rates for lighter soils. |
| | | | Rates are given for overall sprays; reduce proportionately if only rows are sprayed. |
| | | | **Do NOT** use on fields that will be removed after harvest. |
| linuron | 1.75 to 2.25 kg/ha | | PRE – Disk before any shoots appear in the spring on established plantings. |
| LOROX DF (50 DF) | 3.5 to 4.5 kg/ha | 1.4 to 1.8 kg/ac | A second application may be made after the post-harvest disking. |
| AFOLAN F (480 g/L) | 3.64 to 4.69 L/ha | 1.46 to 1.88 L/ac | Use lower rates for lighter soils. |
| LINURON 480 (480 g/L) | 3.64 to 4.69 L/ha | 1.46 to 1.88 L/ac | Rates are given for overall sprays; reduce proportionately if only rows are sprayed. |
| metribuzin | 1.1 to 2.25 kg/ha | | PRE – Disk before any shoots appear in the spring on established plantings. |
| SENCOR 75 DF (75 WG) | 1.46 to 3 kg/ha | 0.58 to 1.2 kg/ac | A second application may be made after the post-harvest disking. |
| LEXONE DF (75 DF) | 1.46 to 3 kg/ha | 0.58 to 1.2 kg/ac | Use lower rates for lighter soils. |
| EVICT SOLUPAK 75 DF (75 DF) | 1.46 to 3 kg/ha | 0.58 to 1.2 kg/ac | Rates are given for overall sprays; reduce proportionately if only rows are sprayed. |
| simazine | 1.1 to 2.2 kg/ha | | PRE – Disk before any shoots appear in the spring on established plantings. |
| PRINCEP NINE-T (90WG) | 1.2 to 2.4 kg/ha | 0.5 to 1 kg/ac | Use lower rates for lighter soils. |
| plus napropamide | 4.5 to 6.7 kg/ha | | Make only one application per season. |
| DEVRINOL 50W (50WP) | 9 to 13.4 kg/ha | 3.6 to 5.36 kg/ac | **Do NOT** apply within 6 days of harvest. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| simazine | 2.2 to 3.4 kg/ha | | PRE – Apply preemergence to crop, 7 days before first cutting. |
| PRINCEP NINE-T (90WG) | 2.5 to 3.75 kg/ha | 1 to 1.5 kg/ac | Use **ONLY** on established plantings 3 years or older. |
| SIMADEX (500 g/L) | 4.5 to 6.7 L/ha | 1.8 to 2.68 L/ac | A second application may be made after the post-harvest disking. |
| SIMAZINE 480 (480 g/L) | 4.7 to 7 L/ha | 1.88 to 2.8 L/ac | Use lower rates for lighter soils. |
| | | | Rates are given for overall sprays; reduce proportionately if only rows are sprayed. |
| | | | **Do NOT** use on fields that will be removed after harvest. |
| terbacil | 0.3 kg/ha | | PRE – Apply before spears emerge or immediately after clean cutting. |
| SINBAR (80 WP) | 0.375 kg/ha | 0.15 kg/ac | Apply **ONLY** on established asparagus beds. |
| | | | Apply **ONLY** once throughout the entire growing season. |
| | | | Apply before weeds emerge or to small, actively growing weeds (up to 5 cm). |
| | | | **Do NOT** use on soils containing less than 1% organic matter or where subsoil or roots are exposed. |
| | | | **Do NOT** use on plants that are weak or diseased, or lacking in vigour (slow growing). |
| | | | **Do NOT** harvest within 5 days of treatment. |
| | | | Treated areas may be replanted to asparagus the following year after application. |
| | | | **Do NOT** plant any other crop for 2 years. |

## 2nd Year and Established Asparagus — Postemergence Herbicides

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For annual grass, use 0.32 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| plus surfactant/solvent | | | For volunteer grains, use 0.47 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. |
| | | | Use 100 to 200 L water/ha (40 to 80 L water/ac). |
| | | | Grasses emerging after application will not be controlled. |
| | | | Spray tips angled forward 45° will give better coverage. |
| | | | **Do NOT** use flood jet or hollow cone nozzles. |
| | | | **Do NOT** apply if rain is expected within 1 hour after application. |
| | | | Preharvest interval is 40 days. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **2nd Year and Established Asparagus — Postemergence Broadleaf and Grass Herbicides** | | | |
| glufosinate ammonium<br>IGNITE (150 g/L) | 0.405 to 0.75 kg/ha<br>2.7 to 5 L/ha | 1.08 to 2 L/ac | To control fall-seeded rye and emerged weeds.<br>Apply in the spring before spears emerge.<br>Apply in 110 to 330 L/ha (44 to 132 L/ac) water.<br>Weeds that have not emerged will not be controlled. |
| glyphosate<br>ROUNDUP (356 g/L) | 0.45 to 0.89 kg/ha<br>1.25 to 2.5 L/ha | 0.5 to 1 L/ac | For control of fall-seeded rye and emerged weeds.<br>Apply in the spring before spears emerge, but not closer than 7 days to harvest.<br>**ONLY** 1 application per year may be used. |
| **3rd Year and Established Asparagus — Before Spear Emergence or After Last Cutting (Soil-Applied Grass Herbicide)** | | | |
| trifluralin<br>TREFLAN EC (480 g/L)<br>RIVAL EC (500 g/L)<br>BONANZA 400 (400 g/L) | 1 to 2 kg/ha<br>2.08 to 4.16 L/ha<br>1.99 to 3.99 L/ha<br>2.5 to 5 L/ha | <br>0.83 to 1.66 L/ac<br>0.79 to 1.59 L/ac<br>1 to 2 L/ac | PPI – Application should occur early enough in the spring to ensure that spears are not injured by the required incorporation (5 to 10 cm).<br>Apply after last cutting of spears (post-harvest disking) and incorporate.<br>Use **ONLY** on established plantings of 3 years or older. |
| **2nd Year & Established Asparagus — Before Spear Emergence or After Last Cutting (Postemergence Grass & Broadleaf Herbicides)** | | | |
| paraquat<br>GRAMOXONE (200 g/L) | 0.6 to 1.1 kg/ha<br>3 to 5.5 L/ha | 1.2 to 2.2 L/ac | Apply in 300 to 1,100 L/ha (120 to 440 L/ac) water. Use the higher volume of water on dense weed growth.<br>Apply to weed seedlings before asparagus tips appear or after the last cutting.<br>**Do NOT** apply to emerged spears which are to be used for human consumption. |
| **2nd Year and Established Asparagus — During Harvest Immediately After Cutting (Postemergence Broadleaf Herbicide)** | | | |
| 2,4-D *<br>2,4-D (470 g/L)<br>* Various formulations available. See Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271. See label for specific uses and rates. | 1.293 kg/ha<br>2.75 L/ha | 1.1 L/ac | Apply in 50 to 200 L/ha (20 to 80 L/ac) water.<br>May be applied early in the season just after a cutting.<br>Spray immediately after a close harvest to avoid injury.<br>Emerging spears may be twisted and should be discarded. Later emerging spears will be normal. |

# ASPARAGUS

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active)**<br>**PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| **2nd Year and Established Asparagus — After Last Cutting (Postemergence Broadleaf Herbicides)** | | | |
| 2,4-D *<br>2,4-D (470 g/L)<br>* Various formulations available. See Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271. See label for specific uses and rates. | 0.94 to 1.293 kg/ha<br>2 to 2.75 L/ha | <br>0.8 to 1.1 L/ac | Apply in 50 to 200 L/ha (20 to 80 L/ac) water.<br>Apply 3 weeks after the post cutting disking.<br>Direct spray to avoid wetting the asparagus fern. |
| **2nd Year and Established Asparagus — After Last Cutting (Postemergence Grass Herbicides)** | | | |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | <br>0.27 L/ac | Apply to asparagus only after the spears have been harvested.<br>**Do NOT** treat spears prior to or during harvest.<br>Apply when majority of annual grasses are in the 1- to 6-leaf stage or until volunteer corn is up to 25 cm tall.<br>Grasses emerging after application will not be controlled. |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For volunteer grains, use 0.47 L/ha. Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For quackgrass, use 1.1 L/ha. Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within one hour after application.<br>Preharvest interval is 40 days. |
| **2nd Year and Established Asparagus — After Last Cutting (Postemergence Grass and Broadleaf Herbicides)** | | | |
| glufosinate ammonium<br>IGNITE (150 g/L) | 0.405 to 0.75 kg/ha<br>2.7 to 5 L/ha | <br>1.08 to 2 L/ac | Apply in 110 to 330 L/ha (44 to 132 L/ac) water.<br>Spray uniformly on emerged weeds prior to emergence of the fern.<br>Weeds that have not emerged will not be controlled. |

# BEANS (LIMA AND SNAP)

All treatments should be applied in 150–300 L/ha (60–120 L/ac) water unless otherwise specified.

Cultivation, rotation and other cultural practices are effective weed control techniques that should be considered along with herbicide treatments when developing a weed control program. Any single method of weed control or the continuous use of the same chemical can lead to the build-up of weeds resistant or tolerant to that control method. Rotation to other crops and/or other control methods will reduce the chance of developing new or unique weed infestations.

High speed (10–20 km/h), shallow (2.5–3 cm) cultivation with a rotary hoe when the beans are in the 1- to 2-leaf stage will help control small weed seedlings. This technique will not reduce herbicide action and may in some years enhance chemical weed control and improve crop safety.

Inter-row cultivation may be required when weeds escape herbicide treatment; weeds should be considered as escapes when they are 5–7 cm high. Cultivation should be shallow to prevent exposure of untreated soil and germination of new weed seeds.

Band treatment of chemical over the row will reduce costs by one-half to two-thirds, depending on the row spacing and width of band. Shallow inter-row cultivation will be required to control weeds between the bands.

Cultivation will give some control of established perennial weeds but may also help spread them to previously uninfested areas. Machinery sanitation is important when moving from one field to another.

Many perennials can be spread on tillage equipment. Where possible, it is always a good idea to till fields with perennial weeds last. Custom operators should be particularly careful when moving from one farm to another. Some chemicals may also be impregnated on dry bulk fertilizer. Check the label for recommended fertilizer ingredients. See Table 7–9, *Beans (Lima and Snap) Herbicide Weed Control Ratings*, on page 211, to determine which beans are registered for the herbicide treatments listed.

Rates and application techniques vary for trifluralin products. For further information on these and other chemicals, refer to label recommendations and Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.

Soil-applied treatments include:

**Preplant (PP)** — See *Preplant-Site Preparation Prior to Any Crop*, on page 194, for details of products, rates and remarks.

**Preplant Incorporated (PPI)** — Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/h) or vibrating shank S-tine cultivator (10–13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**Preemergence (PRE)** — Rainfall of 15–20 mm within 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

**Postemergence (POST)** — Leaf stage of the weeds is critical for good weed control. Smaller weeds are usually more sensitive to herbicide injury. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

# BEANS (LIMA AND SNAP)

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Soil-Applied Grass Herbicides** | | | |
| EPTC | 3.4 to 4.4 kg/ha | | Apply PPI. Incorporate immediately. |
| EPTAM (800 g/L) | 4.25 to 5.5 L/ha | 1.7 to 2.2 L/ac | If dry weather has preceded the application of EPTC, delay seeding 7–10 days. |
| | | | Temporary injury can occur in the emerging crop. |
| | | | Use the high rate for nut sedge control. |
| EPTC | 2.4 kg/ha | | Apply PPI. Incorporate immediately. |
| EPTAM (800 g/L) | 3 L/ha | 1.2 L/ac | Use ONLY on snap beans. |
| plus trifluralin | 0.6 kg/ha | | If dry weather has preceded the application of EPTC, delay seeding 7–10 days. |
| TREFLAN EC (480 g/L) | 1.25 L/ha | 0.5 L/ac | |
| RIVAL (500 g/L) | 1.2 L/ha | 0.48 L/ac | |
| BONANZA 400 (400 g/L) | 1.5 L/ha | 0.6 L/ac | |
| s-metolachlor | 1.05 to 1.6 kg/ha | | Apply PPI for control of yellow nut sedge. |
| DUAL MAGNUM (915 g/L) | 1.15 to 1.75 L/ha | 0.44 to 0.7 L/ac | Do NOT use on muck, peat or high organic matter soils. |
| | | | Use the higher rate for heavier weed populations. |
| trifluralin | 0.6 to 1.155 kg/ha | | Apply PPI. Incorporate as soon as possible within 24 hr. |
| TREFLAN EC (480 g/L) | 1.25 to 2.4 L/ha | 0.5 to 0.96 L/ac | Do NOT exceed 1.2 L/ha (0.48 L/ac) of TREFLAN on medium-textured soils and 1.7 L/ha (0.68 L/ac) in heavy-textured soils for lima beans. |
| RIVAL (500 g/L) | 1.2 to 2.3 L/ha | 0.48 to 0.92 L/ac | |
| BONANZA 400 (400 g/L) | 1.5 to 2.75 L/ha | 0.6 to 1.1 L/ac | |
| **Soil-Applied Broadleaf Herbicides** | | | |
| metobromuron | 1 to 1.7 kg/ha | | Apply PRE. |
| PATORAN FL (400 g/L) | 2.5 to 4.25 L/ha | 1 to 1.7 L/ac | DO NOT exceed 3.0 L/ha (1.2 L/ac) for snap beans. |
| | | | Use the low rate when applied sequentially after a PPI treatment. |
| | | | Beans should be seeded at least 5 cm deep. Shallow planted crops may be injured if heavy rains follow application. |
| | | | Injury may occur if beans are under stress, or from treated soil having been splashed up onto the leaves by a rainstorm. |
| | | | A shallow harrowing or rotary hoeing after application of the chemical will reduce the possibility of splash-up as well as help activate the chemical if dry weather follows application. |

| **Active Ingredient TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| monolinuron<br>AFESIN (200 g/L) | 0.75 to 1.4 kg/ha<br>3.75 to 7 L/ha | <br>1.5 to 2.8 L/ac | Apply PRE.<br>DO NOT use on soils with less than 3% organic matter.<br>Use the low rate when applied sequentially after a PPI treatment.<br>Beans should be seeded at least 5 cm deep. Shallow-planted crops may be injured if heavy rains follow application.<br>Injury may occur if beans are under stress or from treated soil having been splashed up onto the leaves by a rainstorm.<br>A shallow harrowing or rotary hoeing after application of the chemical will reduce the possibility of splash-up as well as help activate the chemical if dry weather follows application. |
| **Soil-Applied Grass and Broadleaf Herbicides** | | | |
| imazethapyr<br>PURSUIT (240 g/L) | 0.075 kg/ha<br>0.312 L/ha | <br>0.125 L/ac | Apply PRE on snap beans ONLY.<br>Apply once per season.<br>Do NOT harvest within 100 days of application.<br>Some rotational cropping restrictions apply (see Table 7–5, *Herbicide Crop Rotation and SoilpH Restrictions – Horticultural Crops*, on page 192, and Table 7–6, *Herbicide Crop Rotation and Soil pH Restrictions – Field Crops*, on page 193). |
| **Postemergence Grass Herbicides** | | | |
| diclofop-methyl<br>HOE-GRASS 284 (284 g/L) | 1 kg/ha<br>3.5 L/ha | <br>1.4 L/ac | Apply POST when annual grasses are in the 1- to 4-leaf stage (2- to 3-leaf is optimum).<br>Do NOT apply if rain is expected within 1 hr after application. |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | <br>0.27 L/ac | Apply POST when annual grasses are in the 2- to 5-leaf stage.<br>Use ONLY on snap beans.<br>Do NOT apply if rain is expected within 1 hr after application. |
| quizalofop-p-ethyl<br>ASSURE II (96 g/L)<br>plus oil concentrate<br>CANPLUS 411<br>or SURE-MIX | 0.036 to 0.07 kg/ha<br>0.38 to 0.75 L/ha<br><br>5 to 10 L/1,000L<br>5 L/1,000L | <br>0.15 to 0.3 L/ac<br><br>5 to 10 L/1,000L<br>5 L/1,000L | Apply to emerged annual grasses and volunteer cereals in 2-leaf to tillering stage and volunteer corn and quackgrass in the 2- to 6-leaf stage.<br>Use the 0.38 L/ha (0.15 L/ac) rate of ASSURE II for control of volunteer corn, volunteer cereals and green foxtail.<br>The 0.5 L/ha (0.2 L/ac) rate of ASSURE II will suppress quackgrass and also control barnyard grass.<br>Use the 0.75 L/ha (0.3 L/ac) rate of ASSURE II for control of quackgrass.<br>Use the higher rate of CANPLUS 411 or SURE-MIX when wild oats and quackgrass are the target weeds or under drought conditions.<br>Registered for use on snap beans ONLY. |

# BEANS (LIMA AND SNAP)

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply POST when annual grasses and volunteer cereals are in the 1- to 6-leaf stage and quackgrass is in the 1- to 3-leaf stage.<br>Maximum rate on snap beans is 0.65 L/ha (0.26 L/ac).<br>Use the intermediate rate (0.47 L/ha) for volunteer spring cereals.<br>Use the high rate (1.1 L/ha) for quackgrass.<br>Thorough preplant tillage will ensure more uniform quackgrass emergence. Follow with a cultivation 7 days after treatment in wide-row crops.<br>DO NOT apply if rain is expected within 1 hour after application. |
| **Postemergence Broadleaf Herbicides** | | | |
| bentazon<br>BASAGRAN (480 g/L)<br>plus oil concentrate<br>ASSIST | 0.84 to 1.08 kg/ha<br>1.75 to 2.25 L/ha<br><br>2 L/ha | <br>0.7 to 0.9 L/ac<br><br>0.8 L/ac | Apply POST when beans are in the unifoliate to 4-trifoliate-leaf stage.<br>Apply when weeds are small and actively growing.<br>Two applications of 1.75 L/ha (0.7 L/ac) 10 days apart may be required to control the perennial weeds.<br>DO NOT apply if rain is expected within 6 hours after application. |
| fomesafen<br>REFLEX (240 g/L)<br>plus adjuvant<br>AGRAL 90 | 0.24 kg/ha<br>1 L/ha<br><br>2.5 L/1,000L | <br>0.4 L/ac<br><br>2.5 L/1,000L | Apply POST when beans are in the 1- to 2-trifoliate leaf stage.<br>Apply when weeds are small and actively growing.<br>Apply in 200–350 L water/ha (80–140 L/ac water).<br>DO NOT apply if rain is expected within 4 hours after application.<br>DO NOT apply REFLEX to any field more often than once every 2 years.<br>DO NOT apply to crop under stress.<br>Some rotational cropping restrictions apply.<br>DO NOT harvest within 93 days of application. |
| **Postemergence Grass and Broadleaf Herbicides** | | | |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L)<br>plus bentazon<br>BASAGRAN (480g/L)<br>plus oil concentrate<br>ASSIST | 0.054 kg/ha<br>0.67 L/ha<br>0.84 to 1.08 kg/ha<br>1.75 to 2.25 L/ha<br><br>2 L/ha | <br>0.27 L/ac<br><br>0.7 to 0.9 L/ac<br><br>0.8 L/ac | Apply POST when beans are in the unifoliate to 4-trifoliate-leaf stage and annual grasses are in the 2- to 5-leaf stage.<br>USE ONLY on snap beans.<br>Temporary crop injury may occur under abnormally hot, humid conditions. Reduce the oil concentrate to 1 L/ha (0.4 L/ac) when these conditions occur. Apply when weeds are small and actively growing.<br>Refer to the BASAGRAN label for information on specific weed stage and height.<br>If broadleaf and grass weeds are not in the correct leaf stage for a tank-mix application, use a split application at the correct stage for each product.<br>DO NOT apply if rain is expected within 6 hours after application. |

## Table 7–9. Beans (Lima and Snap) Herbicide Weed Control Ratings

Notes: Weed control ratings are given as 0–9 where 0 indicates no control and 9 indicates 90%–100% control under ideal conditions.
Ratings are subjective values based on best available information and give general comparisons based on use as described in this publication.
Crop tolerance ratings are E = Excellent, G = Good, F = Fair, P = Poor.
Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated.
Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.
Ratings in BOLD indicate the weed is listed on the product label for control or suppression.
Please see product label for more information on registered weed species, product uses and precautions.

| | | | Annual Grasses | | | | | | | | Annual Broadleaves | | | | | | | | | | Perennials | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trade Name** | **Lima Beans** | **Snap Beans** | **Barnyard Grass** | **Crabgrass** | **Fall Panicum** | **Foxtail, Giant** | **Foxtail, Green** | **Foxtail, Yellow** | **Old Witch Grass** | **Proso Millet** | **Buckwheat, Wild** | **Fleabane, Canada** | **Lady's-thumb** | **Lamb's-quarters** | **Mustards** | **Nightshades, Annual** | **Pigweeds** | **Ragweed, Common** | **Ragweed, Giant** | **Velvetleaf** | **Bindweed, Field** | **Horsetail** | **Milkweed** | **Nut Sedge** | **Quackgrass** | **Sow-Thistle** | **Thistle, Canada** | **Crop Tolerance** |
| **Soil-Applied Grass Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DUAL MAGNUM | ✔ | ✔ | **9** | **9** | **8/9**[1] | **8** | **9** | **9** | **9** | 4 | 2 | 0 | 2 | 7 | 2 | **8/9**[2] | **7/8** | 4 | 3 | 2 | 0 | 0 | 0 | **8/9**[3] | 0 | 0 | 0 | G |
| EPTAM | | ✔ | **9** | **9** | **9** | **9** | **9** | **9** | **9** | 7 | 4 | 0 | 7 | **7** | 5 | 7 | **7** | 5 | 3 | 5 | ? | ? | ? | **8** | **5** | ? | ? | E |
| RIVAL, TREFLAN or BONANZA | ✔ | ✔ | **9** | **9** | 9 | 9 | 9 | 9 | 9 | 7 | **5** | 0 | 2 | **8** | 2 | 2 | **8** | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | E |
| **Soil-Applied Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AFESIN | ✔ | ✔ | **5** | **5** | 5 | **5** | **5** | **5** | 5 | 5 | **8** | 5 | **9** | **9** | 9 | **7** | **9** | **8** | 6 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | G |
| PATORAN | ✔ | ✔ | **5** | **5** | 5 | 5 | **5** | 5 | **5** | 5 | 8 | 5 | **9** | **9** | **9** | 7 | **9** | **8** | **6** | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | G |
| **Soil-Applied Grass and Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PURSUIT | | ✔ | 8 | 7 | 7 | 9 | **9** | **9** | 8 | **7** | 8 | 2 | **9** | **9** | **9** | **9** | **9** | **8** | 6 | **9** | 2 | 2 | 2 | 7 | 6 | 2 | 2 | G |
| **Postemergence Grass Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ASSURE II | | ✔ | **9** | 8 | 9 | 9 | **9** | 8 | **9** | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | E |
| EXCEL SUPER | | ✔ | **9** | **8** | **9** | 9 | **9** | **8** | **9** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | E |
| HOE-GRASS 284 | ✔ | ✔ | **8** | 5 | **8** | 8 | **9** | **8** | **8** | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | E |
| POAST ULTRA[4] | ✔ | ✔[4] | **9** | **8** | **9** | **9** | **9** | **9** | **9** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | E |
| **Postemergence Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BASAGRAN | ✔ | ✔ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | **5** | **9** | **8** | **9** | 7 | **7** | **8** | **6** | 9 | **6** | 2 | 2 | 8 | 0 | 5 | **7** | G |
| REFLEX | ✔ | ✔ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 2 | **8** | **6** | **9** | **8** | **9** | **9** | **7** | **6** | ? | ? | ? | ? | ? | ? | ? | F |
| **Postemergence Tank-mixes** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EXCEL SUPER + BASAGRAN | | ✔ | **9** | **8** | **9** | **9** | **9** | **8** | **9** | **9** | 7 | **5** | **9** | **8** | **9** | 7 | **7** | **8** | **6** | 9 | **5** | 2 | 2 | **8** | 1 | 5 | **7** | G |

? = Insufficient information available to make a rating.

---

[1] Use the high rate of herbicide for optimum control.

[2] Use PRE timing for optimum control.

[3] Use PPI timing for optimum control.

[4] POAST ULTRA (quackgrass rate: 1.1 L/ha) is not registered for use on snap beans.

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|

## BEETS (SUGAR) — SEE SUGARBEETS

## BEETS (TABLE)

### Site Preparation Before Planting — See Table 7-7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.

PREPLANT INCORPORATED (PPI) Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

PREEMERGENCE (PRE) Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

### Beets (Table) — Soil-Applied Grass Herbicides

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| cycloate<br>RO-NEET (720 g/L) | 3.42 to 4.5 kg/ha<br>4.75 to 6.25 L/ha | 1.9 to 2.5 L/ac | PPI — Apply to a dry soil surface before planting and incorporated.<br>Apply in 150 to 300 L/ha (60 to 120 L/ac) water.<br>Use on mineral soils only. Not usually effective on highly organic soils.<br>Use the lower rate on sandy soils. |

### Beets (Table) — Soil-Applied Broadleaf Herbicides

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| pyrazon<br>PYRAMIN FL (430 g/L) | 3.54 to 4.4 kg/ha<br>8.25 to 10.25 L/ha | 3.3 to 4.1 L/ac | PRE – Apply in 150 to 300 L/ha (60 to 120 L/ac) water.<br>Do NOT use on soils less than 3% organic matter.<br>Rainfall or irrigation is required to activate herbicide. |
| pebulate<br>TILLAM (720 g/L) | 4.5 to 8.82 kg/ha<br>6.25 to 12.25 L/ha | 2.5 to 4.9 L/ac | PPI – Apply to a dry soil surface before planting and incorporated.<br>Apply in 150 to 300 L water/ha (60 to 120 L/ac).<br>Use on mineral soils ONLY. Not usually effective on highly organic soils.<br>Use lower rate on sandy soils. |

### Beets (Table) — Postemergence Broadleaf Herbicides

POSTEMERGENCE Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| pyrazon<br>PYRAMIN FL (430 g/L)<br>plus CITOWETT PLUS<br>SUPER SPREADER STICKER | 3.54 kg/ha<br>8.25 L/ha<br>2.5 L/1,000 L water | 3.3 L/ac<br>2.5 L/1,000 L water | For best results, apply before third true beet leaf or broadleaf weeds.<br>Apply in 300 to 400 L/ha (120 to 160 L/ac) water.<br>Do NOT use any other oils or surfactants, including ASSIST or MERGE or crop injury may result. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Beets (Table) — Postemergence Grass and Broadleaf Herbicides** | | | |
| phenmedipham<br>SPIN-AID (150 g/L) | 0.75 to 1 kg/ha<br>5 to 6.6 L/ha | <br>2 to 2.64 L/ac | Apply when weeds are past cotyledon up to the 4-true-leaf stage, and red beets are past the 3-true-leaf stage. Red beets in the cotyledon stage may be scorched.<br>Do NOT apply more than twice per season.<br>Use a maximum of 28 L of water/L SPIN-AID.<br>May cause temporary growth retardation and/or chlorosis or tip burn on red beets. Beets usually resume normal growth within 10 days.<br>Do NOT spray while dew is present.<br>Do NOT spray if rainfall is expected within 6 hours, or weed kill may be reduced.<br>Delay application until evening if days are hot (30°C or over) or rapid climatic change from cool, overcast days. Do NOT apply if beets are under stress. |

## CABBAGES, CAULIFLOWER, BROCCOLI, BRUSSELS SPROUTS

### Site Preparation Before Planting — See Table 7–7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

| | | | |
|---|---|---|---|
| **Cabbages, Cauliflower, Broccoli, Brussels Sprouts — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| napropamide<br>DEVRINOL DF (50 DF) | 1.12 to 2.25 kg/ha<br>2.25 to 4.5 kg/ha | <br>0.9 to 1.8 kg/ac | PPI or PRE — Use **ONLY** on transplanted cabbages, cauliflower and broccoli.<br>Use **ONLY** one application per year.<br>Use the lower rate on light soils (coarse-textured to sandy and sandy loam).<br>Apply to well-worked soil that is dry enough to permit thorough incorporation to a depth of 2.5 to 5.0 cm.<br>Incorporate the same day as applied.<br>Damage to subsequent cover crops can be reduced by tillage across the rows after harvest.<br>Small grains seeded in the fall may be stunted but not otherwise affected.<br>**Do NOT** harvest within 60 days. |

# CABBAGES, CAULIFLOWER, BROCCOLI, BRUSSELS SPROUTS

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| s-metolachlor<br>DUAL MAGNUM (915 g/L)<br>or s-metolachlor/benoxacor<br>DUAL II MAGNUM (915 g/L) | 1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha<br>1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac<br>0.5 to 0.7 L/ac | PRE to weeds — Apply after transplanting within 2 days, before weeds emerge.<br>Use the higher rate for heavier weed pressure.<br>Apply as a ground application only in 300 L water/ha.<br>Use **ONLY** one application per year.<br>**Do NOT** incorporate, and do not use on seeded cole crops.<br>**Do NOT** apply to soil with less than 1% or more than 10% organic matter.<br>Use **ONLY** on transplanted cabbages, cauliflower and broccoli. |
| trifluralin<br>TREFLAN EC (480 g/L)<br>RIVAL EC (500 g/L)<br>BONANZA 400 (400 g/L) | 0.6 to 1.1 kg/ha<br>1.25 to 2.3 L/ha<br>1.2 to 1.8 L/ha<br>1.5 to 2.75 L/ha | 0.5 to 0.92 L/ac<br>0.48 to 0.72 L/ac<br>0.6 to 1.1 L/ac | PPI<br>Use **ONLY** on direct-seeded cabbages or cauliflower, or on transplants of cabbages, cauliflower, broccoli and Brussels sprouts. |

### Cabbages, Cauliflower, Broccoli, Brussels Sprouts — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| | | | |
|---|---|---|---|
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | 0.27 L/ac | Apply when majority of annual grasses are in the 1- to 6-leaf stage or until volunteer corn is up to 25 cm tall. Grasses emerging after application will not be controlled.<br>**Not registered** for use on Brussels sprouts. |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.1 to 0.25 kg/ha<br>0.8 to 2 L/ha | 0.32 to 0.8 L/ac | Apply to actively growing grasses prior to tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails). Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage for volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly.<br>Thorough preplant tillage, fragmenting quackgrass rhizome improves control.<br>Make one application per season.<br>**Do NOT** cultivate between rows until 5 days after application. |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br>1 to 2 L/ha | 0.13 to 0.45 L/ac<br>0.4 to 0.8 L/ac | Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage.<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac) (**Do NOT** use this rate on broccoli). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>**Do NOT** apply closer than 70 days to harvest.<br>**Do NOT** use on Brussels sprouts.<br>**Do NOT** exceed 0.45 L/ha (0.18 L/ac) on broccoli. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Cabbages, Cauliflower, Broccoli, Brussels Sprouts — Postemergence Broadleaf Herbicides** | | | |
| clopyralid | 0.20 kg/ha | | Apply **POST TRANSPLANT** as a ground application only, in 300 L water/ha (120 L/ac). |
| LONTREL 360 (360 g/L) | 0.56 L/ha | 0.2 L/ac | Use **ONLY** one application per year, no closer than 30 days to harvest. |
| | | | Use **ONLY** on transplanted cabbages, cauliflower and broccoli. |
| pyridate | 0.9 kg/ha | | May be applied following a PPI application of trifluralin. |
| LENTAGRAN (45 WP) | 2 kg/ha | 0.8 kg/ac | Use **ONLY** on direct-seeded or transplanted cabbages. |
| | | | Apply when crop is well established. |

# CARROTS

### Site Preparation Before Planting — See Table 7-7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness, and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

### Carrots — Preplant Incorporated Followed by Postemergence

| | | | |
|---|---|---|---|
| trifluralin | 0.6 to 1.1 kg/ha | | PPI followed by POST. |
| TREFLAN EC (480 g/L) | 1.25 to 2.4 L/ha | 0.5 to 0.96 L/ac | Use on mineral soils. |
| RIVAL EC (500 g/L) | 1.2 to 1.8 L/ha | 0.48 to 0.72 L/ac | Spray linuron when crop has 2 or more fully developed leaves (8 to 15 cm tall). |
| BONANZA 400 (400 g/L) | 1.5 to 2.75 L/ha | 0.6 to 1.1 L/ac | Apply POST before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high. |
| followed by | | | Carrot leaves will become yellow or light green, but they soon recover. |
| linuron | 0.55 to 1.625 kg/ha | | Use nozzle pressure of 175 to 275 kPa. **Do NOT** exceed 275 kPa. |
| LOROX DF (50 DF) | 1.1 to 3.25 kg/ha | 0.44 to 1.3 kg/ac | **Do NOT** apply linuron with herbicidal oil. |
| or linuron | 0.624 to 1.2 kg/ha | | **Do NOT** apply linuron during hot, dry weather (>32°C) or when crop is under stress. |
| AFOLAN F (480 g/L) | 1.3 to 2.5 L/ha | 0.52 to 1 L/ac | **Do NOT apply** linuron if heavy rains are expected. |
| LINURON 480 (480 g/L) | 1.1 to 2.25 L/ha | 0.44 to 0.9 L/ac | Use the lower rates on sandy soils and for smaller weeds. |
| | | | **Do NOT** use on coarse-textured soils low in organic matter. |

# CARROTS

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Carrots — Preemergence Followed by Postemergence** | | | |
| linuron | 0.55 to 1.125 kg/ha | | PRE followed by POST. |
| LOROX DF (50 DF) | 1.1 to 2.25 kg/ha | 0.44 to 0.9 kg/ac | **Do NOT** apply the second treatment sooner than 2 weeks after the first treatment. |
| followed by linuron | 1.125 to 2.25 kg/ha | | **Do NOT** apply more than 2 applications per season. |
| LOROX DF (50 DF) | 2.25 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | Spray POST when crop has 2 or more fully developed leaves (8 to 15 cm tall). |
| OR | | | Apply POST before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high. |
| linuron | 0.624 to 0.912 kg/ha | | Carrot leaves will become yellow or light green, but they soon recover. |
| AFOLAN F (480 g/L) | 1.3 to 1.9 L/ha | 0.52 to 0.76 L/ac | Use nozzle pressure of 175 to 275 kPa. **Do NOT** exceed 275 kPa. |
| followed by linuron | 0.912 to 1.2 kg/ha | | **Do NOT** apply with herbicidal oil. |
| AFOLAN F (480 g/L) | 1.9 to 2.5 L/ha | 0.76 to 1 L/ac | **Do NOT** apply during hot, dry weather (>32°C) or when crop is under stress. |
| OR | | | **Do NOT** apply if heavy rains are expected. |
| linuron | 0.53 to 1.08 kg/ha | | Use the lower rates on sandy soils and for smaller weeds. |
| LINURON 480 (480 g/L) | 1.1 to 2.25 L/ha | 0.44 to 0.9 L/ac | **Do NOT** use on coarse-textured soils low in organic matter. |
| followed by linuron | 1.08 to 2.165 kg/ha | | |
| LINURON 480 (480 g/L) | 2.25 to 4.5 L/ha | 0.9 to 1.8 L/ac | |
| prometryne | 1.8 to 3.4 kg/ha | | PRE followed by POST – Use on muck soils **ONLY**. |
| GESAGARD 480 SC (480 g/L) | 3.75 to 7.08 L/ha | 1.5 to 2.83 L/ac | For POST – Spray when crop has 2 or more fully developed leaves (8 to 15 cm tall). |
| followed by linuron | 0.55 to 1.625 kg/ha | | Apply before annual grasses are 5 cm high and broadleaf weeds are 15 cm high. |
| LOROX DF (50 DF) | 1.1 to 3.25 kg/ha | 0.44 to 1.3 kg/ac | Carrot leaves will become yellow or light green, but they will soon regain their normal colour. |
| or linuron | 0.624 to 1.2 kg/ha | | **Do NOT** apply during hot, dry weather (>32°C) or when crop is under stress. |
| AFOLAN F (480 g/L) | 1.3 to 2.5 L/ha | 0.52 to 1 L/ac | **Do NOT apply** if heavy rains are expected. |
| | | | Use the lower rates for smaller weeds. |
| **Carrots — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| linuron | 0.55 to 1.625 kg/ha | | PRE – Apply as a band or broadcast spray after planting but before carrots emerge. |
| LOROX DF (50 DF) | 1.1 to 3.25 kg/ha | 0.44 to 1.3 kg/ac | Apply in 200 to 350 L/ha (80 to 140 L/ac) water. |
| or linuron | 0.624 to 1.2 kg/ha | | Use the lower rate on sandy soils. |
| AFOLAN F (480 g/L) | 1.3 to 2.5 L/ha | 0.52 to 1 L/ac | Carrots are very sensitive to this treatment at the time of emergence, and severe injury can occur at this time if there is a heavy rain or if the area is irrigated. |
| prometryne | 1.8 to 3.4 kg/ha | | PRE – Apply soon after seeding. |
| GESAGARD 480 SC (480 g/L) | 3.75 to 7.08 L/ha | 1.5 to 2.83 L/ac | Apply in 200 to 1,000 L/ha (80 to 400 L/ac) water. |
| | | | Use the lower rate on sandy soils and the higher rate on muck soils. |
| | | | **Do NOT** use at or near time of emergence. |
| | | | **Do NOT** use for POST use. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| trifluralin | 0.6 to 1.1 kg/ha | | PPI |
| TREFLAN EC (480 g/L) | 1.25 to 2.4 L/ha | 0.5 to 0.96 L/ac | |
| RIVAL EC (500 g/L) | 1.2 to 1.8 L/ha | 0.48 to 0.72 L/ac | |
| BONANZA 400 (400 g/L) | 1.5 to 2.75 L/ha | 0.6 to 1.1 L/ac | |

## Carrots — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS |
|---|---|---|---|
| diclofop-methyl<br>HOE-GRASS 284 (284 g/L) | 1 kg/ha<br>3.5 L/ha | 1.4 L/ac | Apply to annual grasses in the 1- to 4-leaf stages (optimum control at 2- to 3-leaf stages), approximately 10–16 days after emergence.<br>**Do NOT** apply if rain is expected within 1 hour after application. |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | 0.27 L/ac | Apply when majority of annual grasses are in the 1- to 6-leaf stage or until volunteer corn is up to 25 cm tall.<br>Grasses emerging after application will not be controlled.<br>**Do NOT** apply if rain is expected within 1 hour after application. |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.075 to 0.25 kg/ha<br>0.6 to 2 L/ha | 0.24 to 0.8 L/ac | Apply when crop is 10 cm in height or less.<br>Apply to actively growing grasses prior to tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails).<br>Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly.<br>Thorough preplant tillage, fragmenting quackgrass rhizomes improves control.<br>**Do NOT** cultivate between rows until 5 days after application.<br>Apply other postemergence herbicides separately at least 3 days after VENTURE L. |

# CARROTS

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| plus surfactant/solvent<br>MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For volunteer grains, use 0.47 L/ha (0.19 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| | | | For quackgrass, use 1.1 L/ha (0.18 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 49 days. |
| **Carrots — Postemergence Grass and Broadleaf Herbicides** | | | |
| linuron | 1.125 to 2.25 kg/ha | | For carrots not treated with linuron PRE. |
| LOROX DF (50 DF) | 2.25 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | Spray when crop has 2 or more fully developed leaves (8–15 cm tall). |
| or linuron | 0.912 to 2.256 kg/ha | | Apply before annual grasses are 5 cm high and before broadleaf weeds are 15 cm high. |
| AFOLAN F (480 g/L) | 1.9 to 4.69 L/ha | 0.76 to 1.88 L/ac | Carrot leaves will become yellow or light green, but they will soon regain their normal colour.<br>Use nozzle pressure of 175 to 275 kPa. **Do NOT** exceed 275 kPa.<br>**Do NOT** apply with herbicidal oil.<br>**Do NOT** apply during hot, dry weather (>32°C) or when crop is under stress. |
| mineral oil (herbicidal) | | | Apply as soon as true leaves develop and before carrot roots are thicker than a pencil. |
| overall spray | 600 to 800 L/ha | 240 to 320 L/ac | Later treatments may produce an oil flavour. |
| rows only undiluted | 300 to 400 L/ha | 120 to 160 L/ac | Weeds should be less than 10 cm high.<br>Ragweed, wormwood and wild carrot are not controlled. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **CELERY** | | | |
| **Site Preparation Before Planting — See Table 7–7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.** | | | |
| **Celery — Postemergence Grass and Broadleaf Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| linuron<br>AFOLAN F (480 g/L) | 0.9 to 2.25 kg/ha<br>1.87 to 4.68 L/ha | 0.75 to 1.87 L/ac | Apply 8 to 10 days after transplanting.<br>Apply in 150 to 300 L/ha (60 to 120 L/ac) water in the transplanted crop.<br>Some yellowing of the leaves may be noticed but this will be temporary. |
| mineral oil (herbicidal)<br>overall spray<br>rows only undiluted | <br>600 to 800 L/ha<br>300 to 400 L/ha | <br>240 to 320 L/ac<br>120 to 160 L/ac | Apply as the true leaves develop on the celery, before weeds are 10 cm high.<br>Use **ONLY** on outdoor seedbed and **ONLY** if the soil is moist. |
| prometryne<br>GESAGARD 480 SC (480 g/L) | 1.8 to 2.2 kg/ha<br>3.75 to 4.58 L/ha | 1.5 to 1.83 L/ac | **Do NOT** apply until 21 days after transplanting crop when the celery plants are established.<br>Apply in 200 to 1,000 L/ha (80 to 400 L/ac) water in the transplanted crop.<br>**Do NOT** use on direct-seeded crop. |
| **CORN (SWEET) — SEE SWEET CORN** | | | |
| **CUCUMBERS** | | | |
| **Site Preparation Before Planting — See Table 7–7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.** | | | |
| **PREEMERGENCE (PRE)** – Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall. | | | |
| **Cucumbers — Preplant (Stale Seedbed Technique)** | | | |
| glyphosate*<br>glyphosate (360 g/L)<br>* Various formulations available. See Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271. See label for specific uses and rates. | 0.267 to 1.246 kg/ha<br>0.75 to 3.5 L/ha | 0.3 to 1.4 L/ac | Till and fertilize soil in early spring, and then allow weeds to grow.<br>Spray weeds just before seeding crop.<br>Use low rate for small weeds (8 cm), medium rates for weeds 8 to 15 cm and higher rate for weeds over 15 cm tall.<br>Apply recommended PRE or POST herbicides to control new flushes of weeds or use mechanical means of control. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Cucumbers — Soil-Applied Broadleaf Herbicides** | | | |
| naptalam<br>ALANAP (240 g/L) | 2.64 to 7.19 kg/ha<br>11 to 30 L/ha | 4.4 to 12 L/ac | PRE – Apply after seeding cucumbers but before weeds emerge.<br>May also be applied as a POST spray about 1 month after the preemergence spray when the crop has emerged following a clean cultivation. |
| **Cucumbers — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.1 to 0.25 kg/ha<br>0.8 to 2 L/ha | 0.32 to 0.8 L/ac | Apply to actively growing grasses prior to tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails). Apply at 0.8 L/ha (0.32 L/ac) at 2- to 4-leaf stage for volunteer wheat and barley.<br>Apply at 1 to 2 L/ha (0.4 to 0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly.<br>Thorough preplant tillage, fragmenting quackgrass rhizome improves control.<br>**Do NOT** cultivate between rows until 5 days after application.<br>Make one application per season. |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage.<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>**Do NOT** apply closer than 30 days to harvest. |
| **GARLIC** | | | |
| **Site Preparation Before Planting — See Table 7-7, *Non-Selective Herbicides Available for Preplant Site Preparation*, on page 199.** | | | |
| **PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall. | | | |
| **Garlic — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| napropamide<br>DEVRINOL DF (50 DF) | 1.12 to 2.25 kg/ha<br>2.25 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | PRE – One application per year only, prior to crop and weed emergence.<br>Use the lower rate on light soils (coarse-textured to sandy and sandy loam).<br>**Do NOT** apply closer than 60 days to harvest.<br>Damage to subsequent crops and cover crops can be reduced by tillage across the rows after harvest. Small grains seeded in the fall may be stunted but not otherwise affected. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Garlic — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage.<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>**Do NOT** apply closer than 50 days to harvest. |
| **Garlic — Postemergence Broadleaf Herbicides** | | | |
| bromoxynil<br>PARDNER (280 g/L) | 0.28 kg/ha<br>1 L/ha | <br>0.4 L/ac | Apply to actively growing broadleaf weeds at the 1- to 4-leaf stage.<br>Apply in 200 to 300 L water/ha (80 to 100 L water/ac).<br>Apply at 275 kPa.<br>Use one ground application per year **ONLY**.<br>**Do NOT** use flood jet nozzles.<br>**Do NOT** spray at temperatures above 25°C.<br>**Do NOT** apply closer than 58 days to harvest. |

# GINSENG

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

## Ginseng — Postemergence Grass Herbicide

| | | | |
|---|---|---|---|
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | <br>0.8 to 2 L/ha | <br>0.32 to 0.8 L/ac | Apply POST up to 3 times per year: early May, late June and/or mid-August.<br>Apply to actively growing grasses prior to tillering.<br>**Do NOT** apply in the year of harvest. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Ginseng — Postemergence Grass and Broadleaf Herbicide** | | | |
| glyphosate TMS<br>TOUCHDOWN 480 (360 g/L) | 0.9 kg/ha<br>2.5 L/ha | 1.0 L/ac | Apply POST once in the spring before the crop has emerged above the soil.<br>Apply in 50 to 100 L water/ha.<br>Do NOT exceed rate or spray volume as crop injury may result.<br>Do NOT contact actively growing ginseng foliage.<br>Do NOT use a fall application in existing/established gardens. |

# HERBS

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes.

## Herbs — Soil-Applied Grass and Broadleaf Herbicides

| | | | |
|---|---|---|---|
| napropamide<br>DEVRINOL DF (50 DF) | 0.56 to 1.12 kg/ha<br>1.12 to 2.24 kg/ha | 0.45 to 0.9 kg/ac | PRE or PPI – Use on basil ONLY.<br>Apply in 200 to 900 L/ha (80 to 360 L/ac) water.<br>One application per year.<br>Do NOT plant non-labelled crops until 12 months after application to avoid injury.<br>High rates may result in temporary crop stunting or retardation. However, crops will outgrow the injury, and yield is unaffected. |
| terbacil<br>SINBAR (80 WP) | 1.4 kg/ha<br>1.75 kg/ha | 0.7 kg/ac | PRE – Use on peppermint and spearmint ONLY.<br>Apply once per crop season at the end of September to early October.<br>Do NOT apply closer than 9 or 10 months to harvest.<br>Do NOT use on soils with less than 1% OM. |

## Herbs — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.2 kg/ha<br>0.32 to 0.65 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.19 L/ac<br><br>0.4 to 0.8 L/ac | Use on spearmint and peppermint ONLY.<br>Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage.<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass suppression, use 0.65 L/ha (0.26 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass.<br>Apply using 110 to 200 L/ha (44 to 80 L/ac) water.<br>Do NOT apply closer than 30 days to harvest. |

# LEEKS

## Site Preparation Before Planting – See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

## Leeks — Postemergence Grass and Broadleaf Herbicides

| | | | |
|---|---|---|---|
| Prometryne<br>GESAGARD 480 SC (480 g/L) | 1.8 kg/ha<br>3.75 L/ha | <br>1.5 L/ac | Apply 2 applications 10 days apart, before weeds are 5 cm high.<br>Make the first application to well-established transplanted leeks that have produced one new fully expanded leaf.<br>Can be used on either muck or mineral soils.<br>**Do NOT** use more than 2 applications a year.<br>Temporary injury can occur to the lower leaves in some cultivars of leek. |

# LETTUCE

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

## Lettuce — Soil-Applied Grass and Broadleaf Herbicides

| | | | |
|---|---|---|---|
| chlorpropham<br>CIPC EC (480 g/L) | 4.5 to 6.75 kg/ha<br>9.36 to 14 L/ha | <br>3.74 to 5.6 L/ac | PRE.<br>When overhead irrigation is used at seeding time, delay application until after first irrigation but before crop emergence.<br>Use lower rates in cool, wet weather to avoid injury and delay in emergence.<br>Use lower rates in mineral soils. |

# MUSKMELONS, WATERMELONS, SQUASH AND PUMPKINS

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| propyzamide<br>KERB (50 WP) | 2.2 to 4.5 kg/ha<br>4.4 to 9 kg/ha | 1.76 to 3.6 kg/ac | For direct seeded lettuce, apply PPI, PRE, or POST after the crop emerges to weed-free soil.<br>For transplanted lettuce, apply 7 to 10 days after transplanting to weed-free soil.<br>Use only once per year.<br>**Do NOT** replant lettuce in KERB-treated fields in the same year.<br>**Do NOT** use on muck soils.<br>**Do NOT** apply closer than 55 days to harvest. |

## MUSKMELONS, WATERMELONS, SQUASH AND PUMPKINS

### Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

### Muskmelons, Watermelons, Squash and Pumpkins — Soil-Applied Broadleaf Herbicides

| | | | |
|---|---|---|---|
| naptalam<br>ALANAP (240 g/L) | 2.638 to 7.194 kg/ha<br>11 to 30 L/ha | 4.4 to 12 L/ac | **PRE** prior to crop and weed emergence.<br>**Do NOT** use on butternut squash; some injury may occur to Table Queen squash.<br>May be applied to melons (not squash or pumpkins) as a POST about 1 month after the preemergence spray when the crop has emerged but before the weeds are up. |

### Muskmelons, Watermelons, Squash and Pumpkins — Soil-Applied Grass and Broadleaf Herbicides

| | | | |
|---|---|---|---|
| napropamide<br>DEVRINOL DF (50 DF) | 1.12 to 2.25 kg/ha<br>2.24 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | PRE – One application per season.<br>Use on direct-seeded pumpkin and squash **ONLY**.<br>Apply in 200 to 900 L/ha (80 to 360 L/ac) water.<br>Use the lower rate on light soils (coarse-textured, sandy or sandy loam).<br>Shepherd's-purse and lady's-thumb may escape treatment at this rate.<br>Apply before rainfall if irrigation is not available.<br>Damage to subsequent crops and cover crops can be reduced by tillage across the rows after harvest. Small grains seeded in the fall may be stunted but not otherwise affected. |

### Muskmelons, Watermelons, Squash and Pumpkins — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| Active Ingredient<br>**TRADE NAME (Formulation)** | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| sethoxydim<br>POAST ULTRA (450 g/L) | 0.15 to 0.2 kg/ha<br>0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For pumpkins and squash **ONLY**.<br>Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage. |
| plus surfactant/solvent<br>MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>**Do NOT** apply closer than 30 days to harvest. |

# ONIONS

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

Most experience with herbicides below has been with the seeded crop. Experience with sets and limited experience with Spanish onions have been satisfactory. On green bunching onions, the granular formulations (applied when the leaves are dry) are recommended to avoid leaf injury.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes.

## Onions — Soil-Applied Grass and Broadleaf Herbicides

| Active Ingredient<br>**TRADE NAME (Formulation)** | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| chlorpropham<br>CIPC EC (480 g/L)<br>CIPC GR (20 Gr) | 4.5 to 9 kg/ha<br>9.36 to 18.72 L/ha<br>22.5 to 45 kg/ha | 3.74 to 7.49 L/ac<br>9 to 18 kg/ac | PRE or DIRECTED POST – When weed seeds are germinating.<br>Apply these rates on muck soils. Use 9.36 to 14 L/ha (3.74 to 5.6 L/ac) on mineral soils.<br>Cool, moist conditions may result in reduced stand and yields.<br>Avoid onion leaves with directed spray.<br>Excellent control of purslane may be obtained.<br>Groundsel, lamb's-quarters and ragweed are somewhat resistant.<br>**Do NOT** use on bunching onions. |

## Onions — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| Active Ingredient<br>**TRADE NAME (Formulation)** | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS |
|---|---|---|---|
| clethodim<br>SELECT (240 g/L) | 0.09 kg/ha<br>0.38 L/ha | 0.15 L/ac | For control of annual blue grass, other annual grasses and quackgrass.<br>Apply when the crop is in the 1- to 4-leaf stage and the weeds are in the 2- to 6-leaf stage. |
| diclofop-methyl<br>HOE-GRASS 284 (284 g/L) | 1 kg/ha<br>3.5 L/ha | 1.4 L/ac | Apply to annual grasses in the 1- to 4-leaf stage (optimum 2- to 3-leaf stage).<br>Apply 10 to 16 days after emergence.<br>**Do NOT** apply if rain is expected within 1 hour after application. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | 0.27 L/ac | Apply to annual grasses in the 1- to 6-leaf stage or until volunteer corn is 25 cm tall.<br>Annual grasses will not be controlled if emergence occurs after application.<br>**Do NOT** apply if rain is expected within 1 hour after application. |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.075 to 0.25 kg/ha<br>0.6 to 2 L/ha | 0.24 to 0.8 L/ac | Apply to actively growing grasses before tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 4-leaf stage of annual grasses.<br>Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly.<br>Apply in a maximum volume of 300 L/ha (120 L/ac).<br>Thorough preplant tillage, fragmenting quackgrass rhizomes improves control.<br>**Do NOT** cultivate between rows until 5 days after application.<br>**Do NOT** apply closer than 42 days before harvest. |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | 0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | For dry bulb onions **ONLY**.<br>Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage.<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>**Do NOT** apply closer than 50 days to harvest. |
| **Onions — Postemergence Broadleaf Herbicides** | | | |
| oxyfluorfen<br>GOAL 2XL (240 g/L) | 0.12 kg/ha<br>0.5 L/ha | 0.2 L/ac | Apply after onions have 2 fully developed leaves.<br>Apply in minimum of 500 L/ha (200 L/ac) water.<br>**Do NOT** exceed a total of 2.0 L/ha (0.8 L/ac) per year.<br>**Permits** are required from the Ontario Ministry of the Environment and Energy under the *Pesticides Act* for this use. Permit applications should be made to the Ministry of Environment and Energy Pesticide Control Field Officers. See Appendix C, *Ontario Ministry of the Environment and Energy Pesticide Control Offices*, on page 282, for the closest office. |
| **Onions — Postemergence Grass and Broadleaf Herbicides** | | | |
| pendimethalin<br>PROWL 400 (400 g/L) | 1 to 1.5 kg/ha<br>2.5 to 3.75 L/ha | 1 to 1.5 L/ac | For mineral soils, use on direct-seeded dry bulb onions.<br>Apply at the 2-leaf stage and 6-leaf stage of crop development for season-long control.<br>Destroy existing weeds prior to application. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| pendimethalin<br>PROWL 400 (400 g/L) | 3 kg/ha<br>7.5 L/ha | 3 L/ac | For muck soils, use on direct-seeded dry bulb onions.<br>Apply at the loop and/or 2-leaf stage of crop development for season-long control.<br>Destroy existing weeds prior to application. |

# PARSNIPS

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

## Parsnips — Soil-Applied Grass and Broadleaf Herbicides

| | | | |
|---|---|---|---|
| chlorpropham<br>CIPC EC (480 g/L)<br>CIPC (20 Gr) | 4.5 to 9 kg/ha<br>9.36 to 18.72 L/ha<br>22.5 to 45 kg/ha | <br>3.75 to 7.5 L/ac<br>9 to 18 kg/ac | PRE – Apply at time of seeding or until shortly before emergence of crop and weeds.<br>Use the lower rate on mineral soils and the higher rate on muck. |
| linuron<br>AFOLAN F (480 g/L) | 0.624 to 1.2 kg/ha<br>1.3 to 2.5 L/ha | 0.5 to 1 L/ac | PRE – Apply soon after seeding.<br>Apply in 200 to 400 L/ha (80 to 160 L/ac) water.<br>Use lower rate on sandy soil.<br>Heavy rains or irrigation at time of emergence may cause injury. |
| linuron<br>AFOLAN F (480 g/L)<br>followed by linuron<br>AFOLAN F (480 g/L) | 0.624 to 0.912 kg/ha<br>1.3 to 1.9 L/ha<br>0.912 to 1.2 kg/ha<br>1.9. to 2.5 L/ha | <br>0.5 to 0.75 L/ac<br><br>0.75 to 1 L/ac | PRE, followed by POST.<br>These treatments must be at least 2 weeks apart.<br>**Do NOT** apply more than these 2 applications per season. |

## Parsnips — Postemergence Grass and Broadleaf Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| | | | |
|---|---|---|---|
| linuron<br>AFOLAN F (480 g/L) | 0.912 to 2.256 kg/ha<br>1.9 to 4.7 L/ha | 0.76 to 1.88 L/ac | Apply after parsnips are 8 cm tall.<br>**Do NOT** use more than 2.5 L/ha (1 L/ac) on sandy soils.<br>Avoid high temperatures, especially at the higher rate. |
| mineral oil (herbicidal)<br>overall spray<br>rows only undiluted | <br>600 to 800 L/ha<br>300 to 400 L/ha | <br>240 to 320 L/ac<br>120 to 160 L/ac | Apply as soon as true leaves develop and before parsnips roots are pencil thickness.<br>Later treatments may produce an oil flavour.<br>Weeds should be less than 10 cm high. |

<table>
<tr><th>Active Ingredient<br>TRADE NAME (Formulation)</th><th>RATE (active)<br>PRODUCT PER HA</th><th>RATE PRODUCT<br>PER ACRE</th><th>PRECAUTIONS<br>(For more information, see Appendix A, <em>Pesticides Used on Vegetable Crops in Ontario</em>, on page 271.)</th></tr>
<tr><td colspan="4"><strong>PEAS</strong></td></tr>
<tr><td colspan="4"><strong>Site Preparation Before Planting — See <em>Preplant-Site Preparation Prior to Any Crop</em>, on page 194.</strong></td></tr>
<tr><td colspan="4"><strong>PREPLANT INCORPORATED (PPI)</strong> Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.<br><strong>PREEMERGENCE (PRE)</strong> Rainfall of 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.</td></tr>
<tr><td colspan="4"><strong>Peas — Soil-Applied Grass Herbicides</strong></td></tr>
<tr><td>s-metolachlor<br>DUAL MAGNUM (915 g/L)</td><td>1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha</td><td>0.5 to 0.7 L/ac</td><td>Apply PRE.<br><strong>Do NOT</strong> use on muck, peat, high organic matter soils or soils with less than 1% organic matter.<br>Use the higher rate for heavier weed populations.<br>Apply by ground application equipment only.</td></tr>
<tr><td>triallate<br>AVADEX BW (400 g/L)</td><td>1.7 kg/ha<br>4.25 L/ha</td><td>1.7 L/ac</td><td>Apply PPI. Incorporate within 24 hours of application.<br>Use <strong>ONLY</strong> on dry peas.</td></tr>
<tr><td>trifluralin<br>TREFLAN EC(480 g/L)<br>RIVAL EC (500 g/L)<br>BONANZA 400 (400 g/L)</td><td>0.6 to 0.8 kg/ha<br>1.25 to 1.66 L/ha<br>1.2 to 1.59 L/ha<br>1.5 to 2 L/ha</td><td>0.5 to 0.66 L/ac<br>0.48 to 0.64 L/ac<br>0.6 to 0.8 L/ac</td><td>Apply PPI. Incorporate within 24 hours of application.<br><strong>Do NOT</strong> exceed the low rate on medium-textured soils.<br><strong>Do NOT</strong> apply to peat or muck soils (>15% organic matter).<br><strong>Do NOT</strong> apply to soils with less than 2% organic matter.<br><strong>Do NOT</strong> apply to fields spread with manure within the last 12 months.<br><strong>Do NOT</strong> apply by air.</td></tr>
<tr><td colspan="4"><strong>Peas — Soil-Applied Broadleaf Herbicides</strong></td></tr>
<tr><td>prometryne<br>GESAGARD 480 (480 g/L)</td><td>1.8 to 2.2 kg/ha<br>3.75 to 4.58 L/ha</td><td>1.5 to 1.83 L/ac</td><td>Apply PRE — Apply before weeds emerge, including Eastern black nightshade.<br>Apply in 200 to 1,000 L/ha (80 to 400 L/ac) water.<br>Apply only once per year.<br>Use lower rate on sandy soils.<br>Preharvest interval is 55 days.</td></tr>
<tr><td colspan="4"><strong>Peas — Soil-Applied Grass and Broadleaf Herbicides</strong></td></tr>
<tr><td>imazethapyr<br>PURSUIT (240 g/L)</td><td>0.075 kg/ha<br>0.312 L/ha</td><td>0.125 L/ac</td><td>Apply PPI or PRE.<br>Apply only once per year.<br>Allow at least 24 months between PPI applications.<br>Preharvest interval is 60 days.</td></tr>
</table>

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Peas — Postemergence Grass Herbicides** | | | |
| POSTEMERGENCE Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| diclofop-methyl<br>HOE-GRASS 284 (284 g/L) | 0.7 to 0.8 kg/ha<br>2.5 to 2.8 L/ha | 1 to 1.1 L/ac | Apply POST when annual grasses are in the 1- to 4-leaf stage (2- to 3-leaf is optimum) and volunteer corn is 15–25 cm in height.<br>Use the high rate if wild oats are in the 4- to 5-leaf stage.<br>**Do NOT** graze field in the treated year.<br>**Do NOT** apply other herbicides within 4 days of HOE-GRASS application.<br>Apply HOE-GRASS before the use of any POST broadleaf herbicide other than BASAGRAN.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 60 days. |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | 0.27 L/ac | Apply POST when annual grasses are in the 1- to 6-leaf stage and volunteer corn is up to 25 cm tall.<br>**Do NOT** graze treated field prior to harvest.<br>Annual grasses emerging after application will not be controlled.<br>**Do NOT** apply herbicides other than BASAGRAN within 4 days of application.<br>**Do NOT** apply by air.<br>**Do NOT** use flood jet nozzles or controlled droplet application equipment.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 75 days. |

# PEAS

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply POST to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| surfactant/solvent | | | For volunteer grains, use 0.47 L/ha (0.19 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum). |
| MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>**Do NOT** apply herbicides other than MCPA SODIUM 300 or PURSUIT within 4 days of application.<br>**Do NOT** graze treated crop.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Use **ONLY** on fresh or dry processing peas, **NOT** fresh edible pod peas.<br>Preharvest interval is 30 days for fresh processing peas.<br>Preharvest interval is 60 days for dry peas. |
| **Peas — Postemergence Broadleaf Herbicides** | | | |
| bentazon | 0.84 to 1.08 kg/ha | | Apply POST when peas have at least 3 pairs of leaves. |
| BASAGRAN ( /L) | 1.75 to 2.25 L/ha | 0.7 to 0.9 L/ac | Under hot, humid conditions, use CITOWETT PLUS or reduce ASSIST oil concentrate to 1 L/ha (0.4 L/ac). |
| plus surfactant | | | |
| CITOWETT PLUS or | 2.5 L/1,000 L water | 2.5 L/1,000 L water | For snow peas, use the low rate of 1.75 L/ha (0.7 L/ac) and apply only once per year. |
| SUPER SPREADER | 1.25 to 2.5 L/1,000 L | 1.25 to 2.5 L/1,000 L | Refer to the BASAGRAN label for information on specific weed stage and height. |
| STICKER | | | Two applications, 10 days apart, of 1.75 L/ha (0.7 L/ac) may be required for top growth control of nut sedge and Canada thistle, and suppression of field bindweed. |
| or oil concentrate | | | |
| ASSIST | 1 to 2 L/ha | 0.4 to 0.8 L/ac | **Do NOT** apply if rain is expected within 6 hours after application.<br>Preharvest interval is 30 days for snow peas. |
| MCPA | 0.38 kg/ha | | Apply POST when peas are 10 to 15 cm high. |
| MCPA SODIUM 300 (300 g/L) | 1.25 L/ha | 0.5 L/ac | **Do NOT** apply after flower buds have formed on peas. |
| or MCPA | 0.25 kg/ha | | **Do NOT** apply when temperatures are over 27°C, high humidity, or under drought conditions. |
| MCPA AMINE (500 g/L) | 0.5 L/ha | 0.2 L/ac | **Do NOT** apply by air. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| MCPB/MCPA | 1.1 to 1.7 kg/ha | | Apply POST when peas have 3–6 expanded leaves. |
| TROPOTOX PLUS (400 g/L) | 2.75 to 4.25 L/ha | 1.1 to 1.7 L/ac | **Do NOT** apply after the 6-leaf stage as damage may occur. |
| CLOVITOX PLUS (400 g/L) | 2.75 to 4.25 L/ha | 1.1 to 1.7 L/ac | **Do NOT** apply when temperatures are over 27°C, high humidity, or under drought conditions. |
| | | | **Do NOT** apply by air. |
| | | | **Do NOT** graze or cut treated crop for forage. |

# PEPPERS

## Site Preparation Before Planting – See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

All treatments should be applied in 150 to 300 L/ha (60 to 120 L/ac) water.

Discussion of cultural methods can be found in the section *Tomatoes (Transplanted)*, on page 259. Weed control in peppers is best accomplished by combining chemical and cultural methods.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

## Peppers — Soil-Applied Grass Herbicides

| | | | |
|---|---|---|---|
| trifluralin | 0.6 to 1.155 kg/ha | | Apply PPI. Incorporate within 24 hours of application. |
| TREFLAN EC (480 g/L) | 1.25 to 2.4 L/ha | 0.5 to 0.96 L/ac | **Do NOT** exceed the low rate on medium-textured soils. |
| RIVAL EC (500 g/L) | 1.2 to 2.3 L/ha | 0.48 to 0.92 L/ac | **Do NOT** apply to peat or muck soils (>15% organic matter). |
| BONANZA 400 (400 g/L) | 1.5 to 2.75 L/ha | 0.6 to 1.1 L/ac | **Do NOT** apply to soils with less than 2% organic matter. |
| | | | **Do NOT** apply to fields spread with manure within the last 12 months. |
| | | | **Do NOT** apply by air. |
| | | | **Do NOT** apply on the same land for 2 consecutive years. |

## Peppers — Soil-Applied Grass and Broadleaf Herbicides

| | | | |
|---|---|---|---|
| napropamide | 1.12 to 2.25 kg/ha | | Apply PPI. Incorporate within 24 hours of application. |
| DEVRINOL DF (50 DF) | 2.25 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | **Do NOT** apply to soils with over 10% organic matter. |
| | | | Damage to subsequent cover crops can be reduced by tillage across the rows after harvest. |
| | | | Small grains seeded in the fall may be stunted but not otherwise affected. |

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active)**<br>**PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| **Peppers — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage. |
| plus surfactant/solvent | | | For volunteer grains, use 0.47 L/ha (0.19 L/ac). |
| MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>**Do NOT** apply closer than 30 days to harvest. |

# POTATOES

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

The best weed management system for potatoes uses a combination of chemical weed control with cultivation and other techniques. See the section ***Principles of Integrated Weed Management***, on page 158. Cultivation prior to potato emergence using various kinds of cultivation equipment (light harrows, finger weeders, hillers, etc.) will control the early flush of weeds. Root pruning of the crop should be minimized. If the crop is hilled after the application of herbicides, untreated soil will surface and another flush of weeds may result.

**POTATO VINE KILLING** For information on products and rates of application of vine killing, see the section *Vine Killing*, on page 120, and follow the product label.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

### Potatoes — Soil-Applied Grass Herbicides

| | | | |
|---|---|---|---|
| EPTC | 3.4 to 6.8 kg/ha | | PPI — Apply to a dry soil surface before planting and incorporate immediately, at next to the last or last cultivation for grass escapes. Use at 4.25 to 5.4 L/ha (1.7 to 2.2 L/ac). |
| EPTAM (800 g/L) | 4.25 to 8.5 L/ha | 1.7 to 3.4 L/ac | Avoid wet soil conditions or weed control may be poor.<br>Use 5.4 to 8.4 L/ha (2.2 to 3.4 L/ac) rates for heavy weed infestations and nut sedge control. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| s-metolachlor | 1.14 to 1.6 kg/ha | | PRE or PPI (for nut sedge control). |
| DUAL MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | **Do NOT** use on the variety Superior. |
| | | | **Do NOT** use on sandy or coarse-textured soils low in organic matter. |
| | | | **Do NOT** apply at ground crack or if potatoes have emerged. |
| **Potatoes — Soil-Applied Broadleaf Herbicides** | | | |
| linuron | 1.1 to 2.25 kg/ha | | PRE — Apply immediately after hilling, but the potato tops must be covered with soil to |
| LOROX DF (50 DF) | 2.2 to 4.5 kg/ha | 0.88 to 1.8 kg/ac | avoid injury. |
| AFOLAN F (480 g/L) | 2.3 to 4.7 L/ha | 0.92 to 1.88 L/ac | Use the lower rate on light sandy soils and the higher rate on muck or clay soils. |
| LINURON 480 (480 g/L) | 2.3 to 4.7 L/ha | 0.92 to 1.88 L/ac | |
| metobromuron | 1 to 3.4 kg/ha | | PRE — Apply immediately after planting or hilling after potato tops are covered with soil to |
| PATORAN FL (400 g/L) | 2.5 to 8.5 L/ha | 1 to 3.4 L/ac | avoid injury. |
| | | | POST — before weeds are 2.5 cm tall, and potato tops are not exposed. |
| | | | Use the lower rate on light sandy soil, although weed control will be reduced. |
| | | | Use the higher rates on clay and muck soils. |
| | | | Inter-row cultivation may be necessary for full-season control. |
| metribuzin | 0.6 to 1.1 kg/ha | | PRE — Apply after hilling before emergence of crop or weeds, or POST before weeds are |
| SENCOR 500 F (500 g/L) | 1.2 to 2.2 L/ha | 0.48 to 0.88 L/ac | 4 cm tall. |
| or metribuzin | 0.481 to 1.053 kg/ha | | Use the lower rate on sandy soil. |
| LEXONE DF (75 DF) | 0.64 to 1.4 kg/ha | 0.25 to 0.56 kg/ac | **Do NOT** use on muck soils. |
| or metribuzin | 0.41 to 1.16 kg/ha | | **Do NOT** use on Belleisle, Tobique or red-skinned varieties. |
| EVICT SOLUPAK (75 DF) | 0.55 to 1.5 kg/ha | 0.22 to 0.63 kg/ac | **Do NOT** exceed a total application rate of 1.12 kg active/ha. |
| metribuzin | 0.63 to 0.825 kg/ha | | PRE — Apply after hilling and before emergence of the crop, or POST before weeds are 4 cm tall. |
| SENCOR 75 DF (75 WG) | 0.84 to 1.1 kg/ha | 0.34 to 0.44 kg/ac | Use the lower rate on sandy soil. |
| plus linuron | 0.72 to 1.728 kg/ha | | Use the higher rate on late potatoes for season-long control. |
| LINURON 480 (480 g/L) | 1.5 to 3.59 L/ha | 0.6 to 1.44 L/ac | **Do NOT** use on muck soils. |
| | | | **Do NOT** use on Belleisle, Tobique or red-skinned varieties. |
| monolinuron | 1.1 to 2.2 kg/ha | | PRE — Apply immediately after hilling, but all the potato tops must be covered with soil to |
| AFESIN (200 g/L) | 5.5 to 11 L/ha | 2.2 to 4.4 L/ac | avoid injury. |
| | | | Use the lower rate on soils low in organic matter. |
| | | | Use the higher rate on clay or soils high in organic matter. |

# POTATOES

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Potatoes — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| EPTC | 3.4 to 4.4 kg/ha | | PPI. |
| EPTAM (800 g/L) | 4.25 to 5.5 L/ha | 1.7 to 2.2 L/ac | Apply as a tank mix in 220 to 330 L/ha (88 to 132 L/ac) water and incorporate immediately. |
| plus metribuzin | 0.55 to 0.875 kg/ha | | **Do NOT** use on muck soils. |
| SENCOR 500 F (500 g/L) | 1.1 to 1.75 L/ha | 0.44 to 0.7 L/ac | **Do NOT** use on Belleisle or Tobique varieties. |
| or metribuzin | 0.624 to 0.902 kg/ha | | May be applied through the irrigation. |
| LEXONE DF (75 DF) | 0.83 to 1.2 kg/ha | 0.33 to 0.48 kg/ac | |
| or metribuzin | 0.56 to 0.83 kg/ha | | |
| EVICT SOLUPAK (75 DF) | 0.75 to 1.1 kg/ha | 0.3 to 0.44 kg/ac | |
| s-metolachlor | 1.14 to 1.6 kg/ha | | PRE — Apply after the first hilling, before emergence of the crop and weeds. |
| DUAL MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | See "Precautions" in entries for DUAL MAGNUM (915 g/L) and LINURON 480 (480 g/L) (page 233). |
| plus linuron | 0.88 to 1.12 kg/ha | | |
| LOROX DF (50 DF) | 1.75 to 2.25 kg/ha | 0.7 to 0.9 kg/ac | |
| AFOLAN F (480 g/L) | 1.8 to 2.3 L/ha | 0.72 to 0.92 L/ac | |
| LINURON 480 (480 g/L) | 1.8 to 2.3 L/ha | 0.72 to 0.92 L/ac | |
| s-metolachlor | 1.14 to 1.6 kg/ha | | PRE — Apply after the first hilling before emergence of the crop and weeds. |
| DUAL MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | See "Precautions" in entry for DUAL MAGNUM (915 g/L) (page 233). |
| plus metobromuron | 1.168 to 1.68 kg/ha | | Use the lower rates on sandy soil. |
| PATORAN FL (400 g/L) | 2.92 to 4.2 L/ha | 1.17 to 1.68 L/ac | |
| s-metolachlor | 1.14 to 1.6 kg/ha | | PPI or PRE — Apply after the first hilling before emergence of the crop and weeds. |
| DUAL MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | See "Precautions" in entry for DUAL MAGNUM (915 g/L) (page 233). |
| plus metribuzin | 0.55 to 1.125 kg/ha | | **Do NOT** use on Superior, Belleisle or Tobique potatoes. |
| SENCOR 500 F (500 g/L) | 1.1 to 2.25 L/ha | 0.44 to 0.9 L/ac | **Do NOT** apply on sandy or on coarse-textured soils low in organic matter, or on muck soils. |
| or metribuzin | 0.56 to 1.16 kg/ha | | **Do NOT** apply at ground crack or if potatoes have emerged. |
| EVICT SOLUPAK (75 DF) | 0.75 to 1.5 kg/ha | 0.3 to 0.63 kg/ac | |
| or metribuzin | 0.624 to 0.902 kg/ha | | |
| LEXONE DF (75 DF) | 0.83 to 1.2 kg/ha | 0.33 to 0.48 kg/ac | |
| s-metolachlor | 1.14 to 1.6 kg/ha | | PRE — Apply after the first hilling before emergence of the crop and weeds. |
| DUAL MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | See "Precautions" in entry for DUAL MAGNUM (915 g/L) (page 233). |
| plus monolinuron | 1.1 to 1.7 kg/ha | | |
| AFESIN (200 g/L) | 5.5 to 8.5 L/ha | 2.2 to 3.4 L/ac | |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Potatoes — Burndown and Soil-Applied Grass and Broadleaf Herbicide Tank-Mix Options** | | | |
| glufosinate ammonium<br>IGNITE (150 g/L) | 0.405 to 0.75 kg/ha<br>2.7 to 5 L/ha | 1.08 to 2 L/ac | Apply uniformly in 110 to 330 L/ha (44 to 132 L/ac) of water at no later than ground crack of the crop.<br>Only emerged weeds will be controlled. |
| glufosinate ammonium<br>IGNITE (150 g/L)<br>plus metribuzin<br>SENCOR 500 F (500 g/L)<br>LEXONE DF (75 DF) | 0.405 to 0.75 kg/ha<br>2.7 to 5 L/ha<br>0.55 kg/ha<br>1.1 L/ha<br>0.75 kg/ha | 1.08 to 2 L/ac<br>0.44 L/ac<br>0.3 kg/ac | POST – Apply uniformly in 110 to 330 L/ha (44 to 132 L/ac) of water at no later than ground crack of the crop.<br>Only emerged weeds will be controlled.<br>**Do NOT** use metribuzin on muck soils or on Belleisle or Tobique varieties. |
| paraquat<br>GRAMOXONE (200 g/L) | 0.6 to 0.85 kg/ha<br>3 to 4.25 L/ha | 1.2 to 1.7 L/ac | Apply in 275 to 550 L/ha (150 to 220 L/ac) water to emerged weeds.<br>Use on Netted Gem and Cherokee varieties before emergence. Apply on other varieties until 25% to 30% of the crop has emerged but none of the tops should be over 5 to 8 cm in height.<br>Temporary yellowing on the tops will occur.<br>**Do NOT** use on emerged potato plants in the evening, under cloudy conditions or when the plants are under moisture stress. |
| **Potatoes — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| clethodim<br>SELECT (240 g/L)<br>plus surfactant<br>AMIGO | 0.03 to 0.09 kg/ha<br>0.13 to 0.38 L/ha<br>0.5 to 1% v/v<br>5 to 10 L/1,000 L water | 0.05 to 0.15 L/ac<br>0.5 to 1% v/v<br>5 to 10 L/1,000 L water | Potatoes are tolerant at any growth stage.<br>For annual grasses and volunteer cereals, apply at the 2- to 6-leaf stage.<br>For quackgrass, apply at the 2- to 5-leaf stage at the higher rate. |
| diclofop-methyl<br>HOE-GRASS 284 (284 g/L) | 1 kg/ha<br>3.5 L/ha | 1.4 L/ac | **Do NOT** tank-mix with other herbicides.<br>Apply when the majority of the grass weeds are in the 2- to 3-leaf stage.<br>**Do NOT** apply if rain is expected within an hour of application.<br>**Do NOT** apply other postemergence herbicides for 4 days before or after application. |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | 0.27 L/ac | Apply when majority of annual grasses are in the 1- to 6-leaf stage or until volunteer corn is up to 25 cm tall.<br>**Do NOT** apply if rainfall is expected within 1 hour after application.<br>Grasses emerging after application will not be controlled. |

# POTATOES

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| fluazifop-p-butyl | 0.075 to 0.25 kg/ha | | Apply to actively growing grasses before tillering. |
| VENTURE L (125 g/L) | 0.6 to 2 L/ha | 0.24 to 0.9 L/ac | Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails). |
| | | | Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley. |
| | | | Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly. |
| | | | Apply in a maximum volume of 300 L/ha (120 L/ac). |
| | | | Thorough preplant tillage, fragmenting quackgrass rhizomes improves control. |
| | | | **Do NOT** cultivate between rows until 5 days after application. |
| | | | **Do NOT** apply closer than 90 days to harvest. |
| | | | May be tank-mixed with metribuzin. |
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage. |
| surfactant/solvent | | | For volunteer grains, use 0.47 L/ha (0.19 L/ac). |
| MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. |
| | | | Use the high rate of MERGE for quackgrass. |
| | | | Use 100 to 200 L water/ha (40 to 80 L water/ac). |
| | | | **Do NOT** apply closer than 80 days to harvest. |
| **Potatoes — Postemergence Grass and Broadleaf Herbicides** | | | |
| metribuzin | 0.6 to 1.1 kg/ha | | Apply soon after potatoes emerge, and before weeds are 4 cm high. |
| SENCOR 500 F (500 g/L) | 1.2 to 2.2 L/ha | 0.48 to 0.88 L/ac | Apply in the afternoon or early evening on sunny days to allow the enzyme that detoxifies metribuzin to build up. |
| or metribuzin | 0.624 to 0.772 kg/ha | | |
| LEXONE DF (75 DF) | 0.83 to 1.03 kg/ha | 0.33 to 0.4 kg/ac | **Do NOT** use on red-skinned varieties |
| or metribuzin | 0.41 to 1.16 kg/ha | | **Do NOT** use on potatoes grown for the early market. |
| EVICT SOLUPAK (75 DF) | 0.55 to 1.5 kg/ha | 0.22 to 0.63 kg/ac | **Do NOT** use on Shepody or Atlantic potatoes. |
| | | | **Do NOT** use on muck soil to avoid injury on subsequent crops. |
| rimsulfuron | 15 g/ha | | Apply when quackgrass is at 3- to 6-leaf stage (less than 10 cm tall), annual grasses are at 1- to 6-leaf stage and redroot pigweed is in the 4- to 6-leaf stage. |
| PRISM (25DF) | 60 g/ha | 24 g/ac | |
| plus non-ionic surfactant | 0.2% v/v | 0.2% v/v | Apply before potatoes initiate flowering. |
| CITOWETT PLUS, | 2 L/1,000 L water | 2 L/1,000 L water | **Do NOT** apply within 30 days of harvest. |
| AGRAL 90 or AG-SURF | | | Always add water soluble packages to clean water with the agitator running. |

<table>
<tr><th>Active Ingredient<br>TRADE NAME (Formulation)</th><th>RATE (active)<br>PRODUCT PER HA</th><th>RATE PRODUCT<br>PER ACRE</th><th>PRECAUTIONS<br>(For more information, see Appendix A, <i>Pesticides Used on Vegetable Crops in Ontario</i>, on page 271.)</th></tr>
<tr><td colspan="4"><h1>RUTABAGAS</h1></td></tr>
<tr><td colspan="4"><b>Site Preparation Before Planting — See <i>Preplant-Site Preparation Prior to Any Crop</i>, on page 194.</b></td></tr>
<tr><td colspan="4"><b>PREPLANT INCORPORATED (PPI)</b> Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.<br><b>PREEMERGENCE (PRE)</b> Rainfall of 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.</td></tr>
<tr><td colspan="4"><b>Rutabagas — Soil-Applied Grass Herbicides</b></td></tr>
<tr><td>s-metolachlor<br>DUAL MAGNUM (915 g/L)</td><td>1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha</td><td><br>0.5 to 0.7 L/ac</td><td>Apply PPI or PRE. PPI gives optimal control of yellow nut sedge; PRE gives optimal control of Eastern black nightshade.<br><b>Do NOT</b> use on muck, peat, high organic matter soils.<br><b>Do NOT</b> use on soils with less than 1% organic matter.<br>Use the higher rate for heavier weed populations.<br>Apply by ground application equipment only.</td></tr>
<tr><td>trifluralin<br>TREFLAN EC (480 g/L)<br>RIVAL EC (500 g/L)<br>BONANZA 400 (400 g/L)</td><td>0.6 to 1.155 kg/ha<br>1.25 to 2.4 L/ha<br>1.2 to 2.3 L/ha<br>1.5 to 2.75 L/ha</td><td><br>0.5 to 0.96 L/ac<br>0.48 to 0.92 L/ac<br>0.6 to 1.1 L/ac</td><td>Apply PPI. Incorporate within 24 hours of application.<br><b>Do NOT</b> exceed the low rate on medium-textured soils.<br><b>Do NOT</b> apply to peat or muck soils (>15% organic matter).<br><b>Do NOT</b> apply to soils with less than 2% organic matter.<br><b>Do NOT</b> apply to fields spread with manure within the last 12 months.<br><b>Do NOT</b> apply by air.<br><b>Do NOT</b> apply on the same land for 2 consecutive years.</td></tr>
<tr><td colspan="4"><b>Rutabagas — Soil-Applied Grass and Broadleaf Herbicides</b></td></tr>
<tr><td>napropamide<br>DEVRINOL DF (50 DF)</td><td>1.12 to 2.25 kg/ha<br>2.25 to 4.5 kg/ha</td><td><br>0.9 to 1.8 kg/ac</td><td>Apply PPI. Incorporate within 24 hours of application.<br>Use the lower rate on sandy soils.<br><b>Do NOT</b> apply to soils with over 10% organic matter.<br>Damage to subsequent cover crops can be reduced by tillage across the rows after harvest.<br>Preharvest interval is 60 days.</td></tr>
</table>

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Rutabagas — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.075 to 0.25 kg/ha<br>0.6 to 2 L/ha | 0.24 to 0.8 L/ac | Apply POST to actively growing grasses before tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails).<br>Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage will ensure more uniform emergence. Cultivate 7 days after treatment in wide row crops.<br>Apply in a maximum volume of 300 L/ha (120 L/ac).<br>**Do NOT** cultivate between rows until 5 days after application.<br>Apply **ONLY** once per season.<br>**Do NOT** apply other herbicides within 3 days of VENTURE L application.<br>**Do NOT** apply if rain is expected within 2 hours after application.<br>Preharvest interval is 45 days. |
| **Rutabagas — Postemergent Broadleaf Herbicides** | | | |
| clopyralid<br>LONTREL 360 (360 g/L) | 0.2 kg/ha<br>0.56 L/ha | 0.22 L/ac | Apply POST when ragweed is 5 to 10 cm tall.<br>Make **ONLY** one application per year.<br>**Do NOT** apply by air.<br>**Do NOT** apply if rain is expected within 4 hours after application.<br>Preharvest interval is 83 days. |

# SPECIALTY VEGETABLES

## CHINESE BROCCOLI, RADISH & CABBAGE, KOHLRABI, MUSTARD CABBAGE, FUZZY SQUASH, SNOW PEAS

### Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall at 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Specialty Vegetables — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| imazethapyr<br>PURSUIT (240 g/L) | 0.075 kg/ha<br>0.312 L/ha | 0.125 L/ac | PRE — For use on snow peas **ONLY**.<br>Apply **ONLY** once per year.<br>Apply in 200 L/ha (80 L/ac).<br>**Do NOT** apply closer than 60 days to harvest. |
| napropamide<br>DEVRINOL DF (50 DF) | 1.12 to 2.25 kg/ha<br>2.25 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | PRE or PREPLANT — For use **ONLY** on seeded Chinese broccoli, mustard, cabbage, Chinese radish, Chinese cabbage, transplanted Chinese cabbage and kohlrabi.<br>Use the lower rate on light soils (coarse textured to sandy and sandy loam).<br>One application per year. Ground **ONLY.**<br>**Do NOT** apply closer than 60 days to harvest.<br>After harvest, soil should be worked (across rows if banded) to prevent injury to succeeding crops.<br>Small grains seeded in the fall may be stunted but not otherwise affected. |
| napropamide<br>DEVRINOL DF (50 DF) | 1.5 kg/ha<br>3 kg/ha | 1.2 kg/ac | PPI — For use on fuzzy squash **ONLY**.<br>Requires rainfall or sufficient irrigation to wet the soil to a depth of 5 to 10 cm soon after application.<br>Some crop stunting may be observed but this should not affect yield. |
| **Specialty Vegetables — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | 0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | For use **ONLY** on Chinese broccoli, Chinese cabbage, kohlrabi, mustard cabbage and Chinese radish.<br>Apply to actively growing grasses.<br>Apply using 110 to 200 L/ha (44 to 80 L/ac) water volume.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage.<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>**Do NOT** apply closer than 30 days to harvest. |

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Specialty Vegetables — Postemergent Broadleaf Herbicides** | | | |
| bentazon | 0.84 kg/ha | | For snow peas **ONLY**. |
| BASAGRAN (480 g/L) | 1.75 L/ha | 0.7 L/ac | Apply after the crop is at the 3-leaf stage when weeds are small and actively growing. |
| plus oil concentrate | | | Use **ONLY** one application per year. |
| ASSIST | 1 to 2 L/ha | 0.4 to 0.8 L/ac | Apply in 300 L water/ha (120 L water/ac). |
| | | | **Do NOT** apply closer than 30 days to harvest. |
| clopyralid | 0.20 kg/ha | | For use **ONLY** on nappa cabbage, Chinese radish, mustard cabbage and Chinese broccoli. |
| LONTREL 360 (360 g/L) | 0.56 L/ha | 0.2 L/ac | Treat when weeds are young and actively growing. |
| | | | Apply as a ground application in 300 L water/ha. |
| | | | Use **ONLY** one application per year. |
| | | | **Do NOT** apply closer than 30 days to harvest. |
| | | | Will not control weeds that emerge after treatment. |

# SPINACH

### Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall of 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes.

### Spinach — Soil-Applied Grass Herbicides

| | | | |
|---|---|---|---|
| cycloate | 3.4 kg/ha | | PPI — on mineral soils only. |
| RO-NEET (720 g/L) | 4.75 L/ha | 1.9 L/ac | Apply to a dry soil surface before planting and incorporate within 10 min with a double disk, followed soon by a second incorporation at right angles. |

### Spinach — Soil-Applied Broadleaf Herbicides

| | | | |
|---|---|---|---|
| chlorpropham | 1.3 to 5 kg/ha | | PRE — on mineral soils only. |
| CIPC EC (480 g/L) | 2.7 to 10.4 L/ha | 1.08 to 4.16 L/ac | Use higher rates during warm weather (May 1 to October 15) and on heavy soils. |
| | | | Use lower rates during cool season (October 15 to May 1) and on sandy loam soils. |

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Spinach — Postemergence Grass Herbicides** | | | |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>plus surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 49 days. |

# SUGARBEETS (PROCESSING)

**Caution About Herbicide Residues** — Sugarbeets are one of the most sensitive crops to herbicide residues from the previous year's crop. They are particularly sensitive to residues from many of the Group 2 herbicides, including Pursuit, Broadstrike, Classic and Peak. Low soil pH (below 6.0) or high soil pH (above 7.5) can be a factor to delay the breakdown of these herbicides, increasing crop injury in rotational crops. See Table 7–5, *Herbicide Crop Rotation and Soil pH Restrictions – Horticultural Crops*, on page 192, as well as product labels and your herbicide and sugar company representatives for more details on your situation.

## Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

**PREEMERGENCE (PRE)** Rainfall of 15 to 20 mm within 7 to 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

## Sugarbeets (Processing) — Soil-Applied Grass Herbicides

| | | | |
|---|---|---|---|
| cycloate<br>RO-NEET (720 g/L) | 4.5 to 5.58 kg/ha<br>6.25 to 7.75 L/ha | <br>2.5 to 3.1 L/ac | Apply PPI and incorporate immediately.<br>Use lower rate on light sandy soil and higher rate on heavier soil.<br>Use **ONLY** on mineral soils. |

# SUGARBEETS (PROCESSING)

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Sugarbeets (Processing) — Soil-Applied Broadleaf Herbicides** | | | |
| pyrazon<br>PYRAMIN FL (430 g/L) | 3.55 to 4.41 kg/ha<br>8.25 to 10.25 L/ha | 3.3 to 4.1 L/ac | Apply PPI or PRE.<br>**Do NOT** incorporate more than 5 cm deep.<br>**Do NOT** apply to soils with less than 3% organic matter. |
| **Sugarbeets (Processing) — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| ethofumesate<br>NORTRON SC (480 g/L) | 1.54 to 3.96 kg/ha<br>3.2 to 8.25 L/ha | 1.28 to 3.3 L/ac | Apply PPI or PRE.<br>**Do NOT** incorporate more than 5 cm deep.<br>Use **ONLY** on mineral soils.<br>Use the lower rate on soils with less than 3% organic matter.<br>**Do NOT** rotate to other crops for 12 months. |
| ethofumesate<br>NORTRON SC (480 g/L)<br>plus cycloate<br>RO-NEET (720 g/L) | 1.41 to 2.88 kg/ha<br>3.5 to 6 L/ha<br>2.70 to 3.78 kg/ha<br>3.75 to 5.25 L/ha | 1.4 to 2.4 L/ac<br>1.5 to 2.1 L/ac | Apply PPI and incorporate immediately.<br>**Do NOT** incorporate more than 5 cm deep.<br>Use **ONLY** on mineral soils.<br>Use the lower rate on soils with less than 3% organic matter.<br>**Do NOT** rotate to crops other than sugarbeets for 12 months. |
| pebulate<br>TILLAM (720 g/L) | 4.5 to 6.66 kg/ha<br>6.25 to 9.25 L/ha | 2.8 to 3.7 L/ac | PPI – Apply to a dry soil surface before planting and incorporated.<br>Apply in 150 to 300 L water/ha.<br>Use on mineral soils **ONLY**. Not usually effective on highly organic soils.<br>Use lower rate on sandy soils. |
| pyrazon<br>PYRAMIN FL (430 g/L)<br>plus ethofumesate<br>NORTRON SC (480 g/L) | 2.26 kg/ha<br>5.25 L/ha<br>1.75 kg/ha<br>3.65 L/ha | 2.1 L/ac<br>1.46 L/ac | Apply PRE.<br>**Do NOT** apply to soil with less than 2% organic matter.<br>Apply **ONLY** once per year.<br>Use **ONLY** on mineral soils.<br>**Do NOT** rotate to crops other than sugarbeets for 12 months. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| **Sugarbeets (Processing) — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| quizalofop-p-ethyl | 0.036 to 0.072 kg/ha | | Apply POST when annual grasses and volunteer cereals are in the 2-leaf to tillering stage and volunteer corn and quackgrass are in the 2- to 6-leaf stages.<br>Apply before the crop canopy closes to maximize spray coverage.<br>Use the 0.38 L/ha (0.15 L/ac) rate for annual grasses and volunteer cereals.<br>Use the 0.75 L/ha (0.30 L/ac) rate for quack grass.<br>Use a second application of 0.38 L/ha (0.15 L/ac) control late emerging weeds.<br>**Do NOT** exceed an accumulative seasonal use rate of 0.75 L/ha (0.30 L/ac).<br>**Do NOT** use flood jet nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 80 days. |
| ASSURE II (96 g/L) | 0.38 to 0.75 L/ha | 0.15 to 0.30 L/ac | |
| plus oil concentrate | | | |
| CANPLUS 411 | 5 to 10 L/1,000 L water | 5 to 10 L/1,000 L water | |
| or SURE-MIX | 5 L/1,000 L water | 5 L/1,000 L water | |
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply POST to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops.<br>Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>**Do NOT** graze treated crop.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>**Do NOT** apply herbicides other than LONTREL 360 within 4 days of application.<br>Preharvest interval is 85 days. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | |
| plus surfactant/solvent | | | |
| MERGE | 1 to 2 L/ha | 0.4 to 0.8 L/ac | |
| **Sugarbeets (Processing) — Postemergence Broadleaf Herbicides** | | | |
| clopyralid<br>LONTREL 360 (360 g/L) | Consult label and your processor for application rates. | | Apply POST when sugarbeets are in the cotyledon to 8-leaf stage.<br>Preharvest interval is 90 days. |

# SUGARBEETS (PROCESSING)

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| desmedipham<br>BETANEX (150 g/L) | Consult label and your processor for application rates. | | Apply POST when sugarbeets have at least 2 true leaves.<br>Apply before the weeds have 4 true leaves (before 2 true leaves is optimum).<br>Wait a minimum of 7 days before making a second application.<br>Consult label for split (reduced rate) applications.<br>**Do NOT** spray in excess of a total of 16.5 L/ha (6.7 L/ac) of BETANEX per year.<br>**Do NOT** spray under extreme temperatures or drought conditions.<br>**Do NOT** spray if dew is present.<br>Yellowing of the crop may occur, but sugarbeets will recover.<br>**Do NOT** spray if rainfall is expected within 6 hours.<br>Preharvest interval is 60 days. |
| pyrazon<br>PYRAMIN FL (430 g/L)<br>plus surfactant<br>CITOWETT PLUS | Consult label and your processor for application rates. | | Apply POST when true leaf of sugarbeets is at least 2.5 cm long.<br>Apply before the weeds have 3 true leaves.<br>**Do NOT** use on soils with less than 3% organic matter.<br>Avoid hot temperatures.<br>Apply using a minimum of 300 L/ha of water. |
| triflusulfuron-methyl<br>UPBEET (50 DF)<br>plus<br>desmedipham/phenmedipham<br>BETAMIX ((1:1) 150 g/L) | 17.5 to 35 g/ha<br>35 to 70 g/ha<br>0.26 to 0.53 kg/ha<br>1.75 to 3.5 L/ha | 14 to 28 g/ac<br>0.7 to 1.4 L/ac | Apply POST when sugarbeets are actively growing.<br>Yellowing of the crop may occur, but sugarbeets will recover.<br>Make 2 applications 5 to 10 days apart, or as weeds emerge, to weeds with fewer than 4 leaves.<br>Best control is obtained if weeds have less than 2 leaves.<br>Use the closer sequential if the first application was applied to 5 cm (4 true leaves) weeds.<br>Use the higher rate for larger weeds and heavy weed populations.<br>If velvetleaf is the predominant weed, use of UPBEET alone with adjuvant is preferable.<br>**Do NOT** use an adjuvant with this tank mix.<br>**Do NOT** use more than 100 g/ha (40 g/ac) of UPBEET in a season.<br>Avoid hot temperatures.<br>**Do NOT** apply under drought conditions.<br>**Do NOT** apply while dew is present.<br>**Do NOT** spray if rainfall is expected within 6 hours.<br>Preharvest interval is 60 days. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| triflusulfuron-methyl<br>UPBEET (50 DF)<br>plus non-ionic surfactant<br>AGRAL 90, AG-SURF<br>or CITOWETT PLUS<br>or plus adjuvant<br>SURE-MIX | 17.5 to 35 g/ha<br>35 to 70 g/ha<br>0.25% v/v<br>2.5 L/1,000 L water<br><br>0.25% v/v<br>2.5 L/1,000 L water | <br>14 to 28 g/ac<br><br>2.5 L/1,000 L water<br><br><br>2.5 L/1,000 L water | Apply POST when sugarbeets are actively growing.<br>Yellowing of the crop may occur, but sugarbeets will recover.<br>Make 2 applications 5 to 10 days apart when velvetleaf has fewer than 2 leaves.<br>Use the higher rate for larger weeds and heavy weed populations.<br>**Do NOT** use more than 100 g/ha (40 g/ac) of UPBEET in a season.<br>**Do NOT** apply under extreme temperatures or drought conditions.<br>**Do NOT** spray if rainfall is expected within 6 hours.<br>Preharvest interval is 60 days. |
| **Sugarbeets (Processing) — Postemergence Grass and Broadleaf Herbicides** | | | |
| desmedipham/phenmedipham (1:1)<br>BETAMIX (75 g/L: 75 g/L) | Consult label and your processor for application rates. | | Apply POST when sugarbeets have at least 2 true leaves.<br>Yellowing of the crop may occur, but sugarbeets will recover.<br>Best weed control when weeds have fewer than 2 true leaves.<br>A second application may be made if required. Wait at least 7 days.<br>Consult label for split (reduced rate) applications.<br>**Do NOT** spray in excess of a total of 16.5 L/ha (6.7 L/ac) of BETAMIX per year.<br>**Do NOT** apply under extreme temperatures or drought conditions.<br>**Do NOT** apply while dew is present.<br>**Do NOT** spray if rainfall is expected within 6 hours.<br>Preharvest interval is 60 days. |
| desmedipham/phenmedipham (1:1)<br>BETAMIX (75 g/L: 75 g/L)<br>plus endothall<br>HERBICIDE 273 (360g/L) | Consult label and your processor for application rates. | | Apply POST when sugarbeets have 4 to 6 true leaves.<br>Best weed control when weeds have fewer than 2 true leaves.<br>Use lower rate on light, sandy soils.<br>Use the lower rate on smaller sugarbeets or sugarbeets under stress.<br>Apply when average temperature is higher than 15°C for best results.<br>**Do NOT** apply under extreme temperatures or drought conditions.<br>**Do NOT** apply while dew is present.<br>Yellowing of the crop may occur, but sugarbeets will recover.<br>**Do NOT** apply if rainfall is expected within 6 hours.<br>Preharvest interval is 90 days. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| endothall<br>HERBICIDE 273 (360 g/L) | Consult label and your processor for application rates. | | Apply POST when sugarbeets are in the 4- to 6-leaf stages.<br>Best weed control when weeds have fewer than 2 true leaves.<br>Use lower rate on light, sandy soils.<br>Yellowing of the crop may occur, but sugarbeets will recover.<br>Apply when average temperature is higher than 15°C for best results.<br>**Do NOT** apply later than 40 days after emergence. |

## SWEET CORN

**Critical Stage: The critical stage to control weeds in corn is the 2–8 leaf-over stage (3–10 leaf tips).**

**All treatments should be applied in 150–300 L/ha (60–120 L/ac) water unless otherwise specified.**

Any single method of weed control or the continuous use of the same chemicals can lead to the build-up of weeds resistant or tolerant to that control method. Triazine-resistant lamb's-quarters and pigweed have become a problem as a result of continuous corn and the repeated use of triazine herbicides. Rotation to other crops and/or other control methods will reduce the chance of new or unique weed infestations.

Blind harrowing with a set of light harrows operating at a shallow depth before the corn has emerged or using a weeder harrow (with L-shaped flexible tines) when the crop is 5–10 cm high can also help control small annual weed seedlings. High speed (10 km/h), shallow (2.5–3 cm) cultivation with the rotary hoe when corn is 7–8 cm in height will help to control small weed seedlings. These techniques will not reduce herbicide action and may in some years enhance chemical weed control. Inter-row cultivation can be used to complement other weed control measures. Row cultivation is most effective when weeds are small. Cultivation should be shallow to reduce the germination of new weed seeds, to reduce moisture loss and to reduce corn root injury. Inter-row cultivation may be required when weeds escape herbicide treatment; weeds should be considered as escapes when they are 5–7 cm high.

Band treatment of chemical over the row will reduce cost by one-half to two-thirds, depending on the row spacing and width of band. Shallow inter-row cultivation will be required to control weeds between the bands.

Cultivation will give some control of established perennial weeds but may also help spread them to previously uninfested areas. Machinery sanitation is important when moving from one field to another. Many perennials (e.g., nut sedge) can be spread on tillage equipment. Custom operators should be particularly careful when moving from one farm to another.

Sweet corn most frequently is grown in areas where the crops in sequence are very sensitive to atrazine residues. Avoid using atrazine rates above 1.1 kg/ha (active) (2.3 L/ha (0.92 L/ac) of 480 g/L) or 1.2 kg/ha (0.48 kg/ac) of (90 WG) product. (See *Notes on Atrazine and Simazine Soil Residues*, on page 247.)

**Nitrogen** solution can be used as a carrier, instead of water, for preplant and preemergence application of some herbicides. Weed control activity is not increased. Spraying should be done before crop emergence. Consult the herbicide label as to the proper methods of application and use of dispersing agents. Calibrate the sprayer to apply the required amount of nitrogen. Stainless steel flood jet nozzles of adequate size (e.g., Teejet TK SS 5 to TK SS 10) should be used. The nitrogen solution is mildly corrosive, especially to brass, and the sprayer should be cleaned immediately after use. UNITE may be used as an aid in improving liquid fertilizer herbicide compatibility and stability when a simultaneous application of a liquid fertilizer and liquid or wettable powder herbicide is desired. Because formulations and rates vary, it is essential to read the label to determine the exact amount and method to be used.

**Do NOT** apply nitrogen solution with postemergence herbicides.

## Special Notes for Sweet Corn

**Triazine-Resistant Annual Weeds:** Strains of lamb's-quarters, pigweed, ragweed and old witch grass have been found that are resistant to high rates of all TRIAZINE herbicides including atrazine, cyanazine and simazine. These triazine-resistant species have been found in corn-growing areas across Ontario. These strains cannot be visibly distinguished from the susceptible strains. Preemergence treatment with linuron, postemergence treatment with bromoxynil or directed linuron will usually give control of the broadleaf species. The grasses can be controlled with EPTC+ or metolachlor.

### *Notes on Atrazine and Simazine Soil Residues*

Atrazine and simazine residues may last for more than 1 year, particularly if high rates are used more than once and dry weather occurs. If atrazine or simazine is used year after year as in a continuous corn program, triazine residues may be higher. Atrazine when used at rates from 1.2–1.5 kg/ha (active) (2.4–3.0 L/ha (0.96–1.2 L/ac) of (500 g/L) or 1.2–1.7 kg/ha (0.48–0.68 kg/ac) of (90 WG) PRODUCT) on corn generally has not caused injury on succeeding crops of oats, barley, mixed grains or soybeans, except in years where there was very little rain the previous fall, which would slow down atrazine degradation in the soil. Postemergence treatments may persist longer than preemergence treatments. Variations from this generality of 1.2–1.5 kg/ha atrazine may occur across the province.

Injury has been reported on tomatoes, white beans, forage seedlings, peas, tobacco, cucumbers, onions and turnips following applications of atrazine at more than 1.1 kg/ha (0.44 kg/ac) (active) (2.3 L/ha (0.96 L/ac) of (480 g/L) or 1.2 kg/ha (0.48 kg/ac) of (90 WG) PRODUCT) on corn the previous year.

**To reduce the hazard of atrazine residues on succeeding crops:**

- Apply the early postemergence atrazine oil-water treatment with the lower rate of atrazine: 1.1 kg/ha (active) (2.2 L/ha (0.88 L/ac) of (500 g/L) or 1.2 kg/ha (0.48 kg/ac) of (90 WG) PRODUCT). With this lower rate, a lower measure of weed control may result, and cultivation may be necessary.
- Fall plowing will reduce TRIAZINE injury more than will spring plowing.
- Moldboard plowing will disperse herbicide residue to a greater soil depth than chisel plowing, thus reducing the concentration of herbicide in the upper soil area.
- Ensure that the sprayer used is adequate and is properly calibrated and adjusted. Spray uniformly without overlaps and do not spray while the sprayer is stopped.

If a residue problem is anticipated, contact your local crop consultant or dealer for information on soil analysis procedures for triazine residues.

**Soil-applied treatments include:**

- **Preplant (PP)** Also see *Preplant-Site Preparation Prior to Any Crop*, on page 194, for details of products, rates and remarks.
- **Preplant Incorporated (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7–10 km/h) or vibrating shank S-tine cultivator (10–13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.
- **Preemergence (PRE)** Rainfall of 15–20 mm within 10 days after application is necessary to activate preemergence treatments. Shallow cultivation, rotary hoeing or harrowing will control weed escapes and improve herbicide activity in the absence of rainfall.

**Postemergence (POST)** Leaf stage of the weeds is critical for good weed control. Smaller weeds are usually more sensitive to herbicide injury. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

# SWEET CORN

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| **Burndown and Residual Control** | | | |
| See the section *Conservation Tillage*, on page 163, for information on treatments specifically for use in conservation till, minimum-till or no-till systems. | | | |
| atrazine<br>AATREX NINE-O (90WG)<br>AATREX (480 g/L)<br>ATRAZINE 480 (480 g/L)<br>plus paraquat<br>GRAMOXONE (200 g/L) | 1.53 kg/ha<br>1.7 kg/ha<br>3.18 L/ha<br>3.18 L/ha<br>0.55 to 1.1 kg/ha<br>2.75 to 5.5 L/ha | <br>0.68 kg/ac<br>1.27 L/ac<br>1.27 L/ac<br><br>1.1 to 2.2 L/ac | Apply at least 3 days prior to crop emergence.<br>Some perennial species may escape (e.g., alfalfa, bromegrass and orchard grass).<br>Consideration should be given to follow-up treatments when the corn is at the approximate stage of growth with herbicide treatments recommended for use in the conventional tillage corn section.<br>Apply in 325–500 L/ha water (130–200 L/ac). |
| dimethenamid<br>FRONTIER (900 g/L)<br>plus glyphosate<br>ROUNDUP (356 g/L)<br>or plus glyphosate TMS<br>TOUCHDOWN 480 (330 g/L) | 1 to 1.25 kg/ha<br>1.1 to 1.4 L/ha<br>0.89 kg/ha<br>2.5 L/ha<br>0.825 kg/ha<br>2.5 L/ha | <br>0.44 to 0.56 L/ac<br><br>1 L/ac<br><br>1 L/ac | Use the higher rate of FRONTIER for heavier weed populations.<br>Follow with sequential postemergence herbicide for additional broadleaf weed control. |
| dimethenamid<br>FRONTIER (900 g/L)<br>plus atrazine<br>AATREX NINE-O (90WG)<br>plus glyphosate<br>ROUNDUP (356 g/L) | 1 to 1.25 kg/ha<br>1.1 to 1.4 L/ha<br>1 to 1.53 kg/ha<br>1.11 to 1.7 kg/ha<br>0.89 kg/ha<br>2.5 L/ha | <br>0.44 to 0.56 L/ac<br><br>0.44 to 0.68 kg/ac<br><br>1 L/ac | Use the higher rate of FRONTIER for heavier weed populations.<br>Control of non-emerged triazine-resistant weeds will be limited to pigweed. |
| linuron<br>AFOLAN F (480 g/L)<br>plus glyphosate TMS<br>TOUCHDOWN 480 (330 g/L) | 1.8 to 2.26 kg/ha<br>3.75 to 4.7 L/ha<br>0.825 kg/ha<br>2.5 L/ha | <br>1.5 to 1.88 L/ac<br><br>1 L/ac | Apply PRE.<br>Plant corn at least 4 cm deep. Heavy rainfall and adverse weather conditions may result in temporary crop injury.<br>Annual grasses, ragweed and velvetleaf are partially controlled but are the first to escape, particularly if low rates of the herbicide are used.<br>Can be used on selected sweet corn varieties.<br>**Do NOT** use on sandy soils. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| s-metolachlor/benoxacor | 1.14 to 1.6 kg/ha | | Use the higher rate of DUAL II MAGNUM for heavier weed populations. |
| DUAL II MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | Use higher rate of glyphosate when perennial weeds are present. |
| plus glyphosate | 0.84 to 0.89 kg/ha | | Apply in 200 L/ha water (80 L/ac). |
| ROUNDUP (360 g/L) | 2.35 to 2.5 L/ha | 0.94 to 1 L/ac | |
| GLYPHOS (360 g/L) | 2.35 to 2.5 L/ha | 0.94 to 1 L/ac | |
| or plus glyphosate TMS | 0.825 kg/ha | | |
| TOUCHDOWN 480 (330 g/L) | 2.5 L/ha | 1 L/ac | |
| s-metolachlor/benoxacor | 1.14 to 1.6 kg/ha | | Apply preplant burndown application only when emerged weeds are less than 6 cm tall. If emerged annual weeds are taller than 6 cm, apply glyphosate prior to the tank mix application or make an application of 3-way tank mix of DUAL II MAGNUM plus atrazine plus glyphosate.<br>For improved burn-down of small emerged annual weeds, the following additives may be applied:<br>• Crop oil, 28–0–0 or 10–34–0 at 50 L/1,000 L;<br>• Crop oil concentrate at 10 L/1,000 L;<br>• Non-ionic surfactant at 1 L/1,000 L.<br>Use higher rates for heavier weed populations. |
| DUAL II MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | |
| plus atrazine | 1 to 1.53 kg/ha | | |
| AATREX NINE-O (90WG) | 1.11 to 1.7 kg/ha | 0.44 to 0.68 kg/ac | |
| s-metolachlor/benoxacor | 1.14 to 1.6 kg/ha | | Use the higher rate of DUAL II MAGNUM for heavier weed populations.<br>Use higher rate of glyphosate when perennial weeds are present.<br>Many broadleaf perennial weeds may not be controlled at this time and rate of application.<br>For tank-mixtures of PRIMEXTRA II MAGNUM plus any of the glyphosate products, to ensure optimum compatibility: "Add PRIMEXTRA II MAGNUM to the tank first, then add AGRAL 90, AGSURF, COMPANION, ENHANCE, OR FRIGATE at 5 L/1,000 L. Continue agitation and add the glyphosate mix partner."<br>Apply in 200 L/ha (80 L/ac) water. |
| DUAL II MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | |
| plus atrazine | | | |
| AATREX LIQUID 480 (480 g/L) | 2.1 to 3.1 L/ha | 0.85 to 1.5 kg/ac | |
| or | | | |
| s-metolachlor/benoxacor/atrazine | 2.16 to 2.88 kg/ha | | |
| PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) | 3 to 4 L/ha | 1.2 to 1.6 L/ac | |
| plus glyphosate | 0.836 to 0.89 kg/ha | | |
| ROUNDUP (360 g/L) | 2.35 to 2.5 L/ha | 0.94 to 1 L/ac | |
| GLYPHOS (360 g/L) | 2.35 to 2.5 L/ha | 0.94 to 1 L/ac | |
| or glyphosate TMS | 0.825 kg/ha | | |
| TOUCHDOWN 480 (330 g/L) | 2.5 L/ha | 1 L/ac | |

# SWEET CORN

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| **Soil-Applied Grass Herbicides** | | | |
| dimethenamid<br>FRONTIER (900 g/L) | 1 to 1.25 kg/ha<br>1.1 to 1.4 L/ha | 0.44 to 0.56 L/ac | Apply PPI or PRE. Incorporation equipment should be set to work soil no deeper than 10 cm.<br>Control of yellow nut sedge is obtained when FRONTIER is applied PPI. Minimum PPI rate is 1.125 kg/ha (active).<br>Use the higher rate of FRONTIER for the control of nightshade and pigweed.<br>**Do NOT** use on muck, peat or high organic matter soils.<br>See tank mixes for treatments to provide annual broadleaf control or follow with sequential postemergence broadleaf herbicide.<br>**Do NOT** use on seed corn or popcorn. |
| EPTC/ R25788 (EPTC+)<br>ERADICANE (800 g/L) | 3.4 to 4.4 kg/ha<br>4.25 to 5.5 L/ha | 1.7 to 2.2 L/ac | Must be PPI.<br>**Do NOT** use on seed corn. |
| s-metolachlor/benoxacor<br>DUAL II MAGNUM (915 g/L) | 1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | Apply PPI or PRE. Incorporation equipment should be set to work soil no deeper than 10 cm.<br>Control of yellow nut sedge is obtained when DUAL II MAGNUM is applied PPI.<br>Optimal control of nightshade is obtained when DUAL II MAGNUM is applied PRE.<br>**Do NOT** use on muck, peat or high organic matter soils.<br>See tank mixes for treatments to provide annual broadleaf control or follow with sequential postemergence broadleaf herbicide. |
| **Soil-Applied Broadleaf Herbicides** | | | |
| atrazine<br>ATRAZINE 480 (480 g/L)<br>AATREX NINE-O (90WG) | 1.01 to 1.49 kg/ha<br>2.1 to 3.1 L/ha<br>1.12 to 1.65 kg/ha | 0.84 to 1.24 L/ac<br>0.45 to 0.66 kg/ac | Apply PRE.<br>Weeds will normally emerge and die within a few days; atrazine can persist for varying lengths of time; longer under dry, cool weather and coarse-textured soils. See tank mixes for reducing rates and avoiding residues, and for treatments to provide annual grass control. |
| simazine<br>PRINCEP NINE-T (90WG)<br>or simazine<br>SIMADEX (500 g/L)<br>SIMAZINE 480 (480 g/L) | 1.35 to 2.25 kg/ha<br>1.5 to 2.5 kg/ha<br>1.6 to 4 kg/ha<br>3.2 to 8 L/ha<br>3.4 to 8.3 L/ha | 0.6 to 1 kg/ac<br>1.28 to 3.2 L/ac<br>1.36 to 3.32 L/ac | Apply PRE.<br>These products are listed separately because of their widely differing rate ranges. In both cases, the low rates should be used on sandy soils while the higher rates may be used on loams and clays.<br>Full-season annual weed control can be expected except for crabgrass or fall panicum where infestations have built up.<br>Caution is advised that when considering rates beyond 2.0 kg/ha (0.8 kg/ac) as soil residues may be high. |
| **Soil-Applied Grass and Broadleaf Herbicides** | | | |
| cyanazine<br>BLADEX 90 DF (90 DF) | 2.25 to 2.7 kg/ha<br>2.5 to 3 kg/ha | 1 to 1.2 kg/ac | Apply PRE.<br>Barnyard grass and redroot pigweed may escape. Use the low rate on coarse-textured soils and on sweet corn.<br>BLADEX is not recommended alone for fine-textured or muck soils.<br>See other treatments for appropriate tank mixes. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| cyanazine | 2.11 to 2.64 kg/ha | | Apply PPI at these rates.<br>This combination will improve barnyard grass and pigweed control over cyanazine alone.<br>Use the lower rate of both BLADEX and atrazine on coarse-textured soils and the higher rates on medium- to fine-textured soils.<br>**Do NOT** use on muck or peat soils.<br>Mid-season (July) germinating fall panicum may not be controlled. |
| BLADEX 90 DF (90 DF) | 2.35 to 3 kg/ha | 0.94 to 1.2 kg/ac | |
| BLADEX LIQUID (480 g/L) | 4.4 to 5.5 L/ha | 1.76 to 2.2 L/ac | |
| plus atrazine | 1.128 to 1.3 kg/ha | | |
| ATRAZINE 480 (480 g/L) | 2.35 to 2.7 L/ha | 0.94 to 1.08 L/ac | |
| AATREX NINE-O (90WG) | 1.25 to 1.44 kg/ha | 0.5 to 0.58 kg/ac | |
| cyanazine | 1.8 to 2.25 kg/ha | | Apply PRE.<br>The tank mix of BLADEX plus atrazine will improve control on fine-textured soils and control of barnyard grass and redroot pigweed.<br>**Do NOT** use the mixture on muck or peat soils.<br>Fall panicum or velvetleaf may not be controlled for the full season. |
| BLADEX 90 DF (90 DF) | 2 to 2.5 kg/ha | 0.8 to 1 kg/ac | |
| plus atrazine | 1.2 to 1.49 kg/ha | | |
| ATRAZINE 480 (480 g/L) | 2.5 to 3.1 L/ha | 1 to 1.24 L/ac | |
| AATREX NINE-O (90WG) | 1.35 to 1.65 kg/ha | 0.54 to 0.66 kg/ac | |
| dimethenamid | 1 to 1.25 kg/ha | | Apply PREPLANT.<br>Use the higher rate of FRONTIER for heavier weed populations. Control of non-emerged triazine-resistant weeds will be limited to pigweed.<br>For improved burn-down control, the addition of glyphosate may be required. |
| FRONTIER (900 g/L) | 1.1 to 1.4 L/ha | 0.44 to 0.56 L/ac | |
| plus atrazine | 1 to 1.53 kg/ha | | |
| AATREX NINE-O (90WG) | 1.11 to 1.7 kg/ha | 0.44 to 0.68 kg/ac | |
| EPTC/ R25788 (EPTC+) | 3.4 to 6.8 kg/ha | | Apply PPI.<br>For suppression of moderate to heavy infestations of wild proso millet, use the higher rate of ERADICANE with atrazine. For most effective suppression of proso millet, delay treatment and planting until mid- to late May. Cultivation or a directed post application of linuron may be required to control later emerging proso millet.<br>**Do NOT** use on seed corn. |
| ERADICANE (800 g/L) | 4.25 to 8.5 L/ha | 1.7 to 3.4 L/ac | |
| plus atrazine | 1.2 to 1.49 kg/ha | | |
| ATRAZINE 480 (480 g/L) | 2.5 to 3.1 L/ha | 1 to 1.24 L/ac | |
| AATREX NINE-O (90WG) | 1.35 to 1.65 kg/ha | 0.54 to 0.66 kg/ac | |
| EPTC/ R25788 (EPTC+) | 6.8 kg/ha | | Apply PPI.<br>For increased control of proso millet, an inter- to row cultivation should be used.<br>**Do NOT** use on seed corn. |
| ERADICANE (800 g/L) | 8.5 L/ha | 3.4 L/ac | |
| plus cyanazine | 2 to 2.25 kg/ha | | |
| BLADEX LIQUID (480 g/L) | 4.25 to 4.7 L/ha | 1.7 to 1.9 L/ac | |
| BLADEX 90 DF (90 DF) | 2.25 to 2.5 kg/ha | 0.9 to 1 kg/ac | |
| linuron | 1.8 to 2.26 kg/ha | | Apply PRE.<br>Plant corn at least 4 cm deep. Heavy rainfall and adverse weather conditions may result in temporary crop injury.<br>Annual grasses, ragweed and velvetleaf are partially controlled but are the first to escape, particularly if low rates of the herbicide are used.<br>Can be used on selected sweet corn varieties.<br>**Do NOT** use on sandy soils. |
| AFOLAN F (480 g/L) | 3.75 to 4.7 L/ha | 1.5 to 1.88 L/ac | |

# SWEET CORN

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| linuron | 1.082 kg/ha | | Apply PRE.<br>Use this tank mix only on clay or clay loam soil to avoid injury. This tank mix controls annual weeds including triazine-resistant redroot pigweed and lamb's-quarters and is a method of reducing atrazine residues. Annual grasses will be the first weeds to escape.<br>See "Precautions" for linuron alone, on page 251. |
| LOROX DF (50 DF) | 2.2 kg/ha | 0.88 kg/ac | |
| or linuron | 1.08 to 1.56 kg/ha | | |
| LINURON 480 (480 g/L) | 2.25 to 3.25 L/ha | 0.9 to 1.3 L/ac | |
| plus atrazine | 1.1 kg/ha | | |
| ATRAZINE 480 (480 g/L) | 2.29 L/ha | 0.92 L/ac | |
| AATREX NINE-O (90WG) | 1.22 kg/ha | 0.49 kg/ac | |
| s-metolachlor/benoxacor | 1.14 to 1.6 kg/ha | | Apply PPI or PRE. The PPI application may not give full-season control of fall panicum or velvetleaf, but will control nut sedge for most of the season (10–14 weeks): mid-season (July) germinating fall panicum may not be controlled.<br>DUAL II MAGNUM controls the grasses and atrazine controls the broadleaf weeds.<br>Use the high rate where annual grass build-up or nut sedge infestation is evident. |
| DUAL II MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | |
| plus atrazine | 1.01 to 1.49 kg/ha | | |
| ATRAZINE 480 (480 g/L) | 2.1 to 3.1 L/ha | 0.84 to 1.24 L/ac | |
| AATREX NINE-O (90WG) | 1.12 to 1.65 kg/ha | 0.45 to 0.66 kg/ac | |
| or s-metolachlor/benoxacor/atrazine | 2.16 to 2.88 kg/ha | | |
| PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) | 3 to 4 L/ha | 1.2 to 1.6 L/ac | |
| s-metolachlor/benoxacor | 1.14 kg/ha | | Use **ONLY** on sweet corn.<br>Make only ONE application per year.<br>Apply in a minimum of 150 L water/ha.<br>**Do NOT** harvest sweet corn within 50 days of treatment.<br>Apply by ground equipment only. |
| DUAL II MAGNUM (915 g/L) | 1.25 L/ha | 0.5 L/ac | |
| plus linuron | 0.38 to 0.75 kg/ha | | |
| AFOLAN F (480 g/L) | 0.84 to 1.7 L/ha | 0.35 to 0.68 L/ac | |
| plus atrazine | 0.99 to 1.53 kg/ha | | |
| AATREX NINE-O (90WG) | 1.1 to 1.7 kg/ha | 0.45 to 0.69 kg/ac | |
| simazine | 1.35 to 2.25 kg/ha | | Apply PPI or PRE.<br>These products are listed separately because of their widely differing rate ranges. In both cases, the low rates should be used on sandy soils while the higher rates may be used on loams and clays. Full-season annual weed control can be expected except for crabgrass or fall panicum where infestations have built up. Caution is advised when considering rates beyond 2.0 kg/ha (0.8 kg/ac), as soil residues may be high. See the section *Notes on Atrazine and Simazine Soil Residues*, on page 247.<br>**Note**: Maximum registered Simazine 80W rate is 2.75 kg/ha (1.1 kg/ac) (2.2 kg/ha active). |
| PRINCEP NINE-T (90WG) | 1.5 to 2.5 kg/ha | 0.6 to 1 kg/ac | |
| or simazine | 1.6 to 4 kg/ha | | |
| SIMADEX (500 g/L) | 3.2 to 8 L/ha | 1.28 to 3.2 L/ac | |
| SIMAZINE 480 (480 g/L) | 3.4 to 8.3 L/ha | 1.36 to 3.32 L/ac | |
| SIMAZINE 80W (80 WP) | 2 to 2.75 kg/ha | 0.8 to 1.1 kg/ac | |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| **Postemergence Grass Herbicides** | | | |
| nicosulfuron | 25 g/ha | | Always add water soluble packages to clean water with the agitator running.<br>Corn should be within the 1- to 8-leaf stage of growth. Apply ACCENT when annual grasses are in the 1- to 6-leaf stage and/or quackgrass is in the 3- to 6-leaf stage (10–20 cm).<br>**Do NOT** apply ACCENT to corn treated with organophosphorous insecticides.<br>Sweet corn should be in the 1- to 6-leaf stage (4 visible collars).<br>Use **ONLY** on these cultivars: Bonus BT, Calicobelle, CNS 710, Elite, FTF243, FTF246, GH 2690, GSS 7831, and Krispy King.<br>**Do NOT** apply on Delmonte 2038. |
| ACCENT (75 DF) | 33 g/ha | 13 g/ac | |
| plus non-ionic surfactant | | | |
| CITOWETT PLUS,<br>AGRAL 90 or AG-SURF | 2 L/1,000 L | 2 L/1,000 L | |
| s-metolachlor/benoxacor | 1.14 to 1.6 kg/ha | | Corn should be at the spike to 2-leaf stage and annual grasses not beyond the 2-leaf stage.<br>**Do NOT** add oil or surfactants. |
| DUAL II MAGNUM (915 g/L) | 1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | |
| **Postemergence Broadleaf Herbicides** | | | |
| atrazine | 1.01 to 1.49 kg/ha | | Apply from the 4- to 8-leaf stage of corn. A reduced rate of atrazine at 0.5 kg/ha (1/2 the low rate) can be used to control weeds listed for PARDNER (or KORIL) alone plus ragweed up to the 8-leaf stage, velvetleaf and triazine-susceptible red root pigweed up to 6 leaves.<br>Controls a wider spectrum of broadleaf weeds than PARDNER or KORIL alone; larger pigweed, ragweed and velvetleaf will be controlled.<br>**Do NOT** add oil or surfactant.<br>**Do NOT** use formulated atrazine/oil products in this tank mixture. |
| AATREX (480 g/L) | 2.1 to 3.1 L/ha | 0.84 to 1.24 L/ac | |
| AATREX NINE-O (90WG) | 1.12 to 1.65 kg/ha | 0.45 to 0.66 kg/ac | |
| plus bromoxynil | 0.28 kg/ha | | |
| PARDNER (280 g/L) | 1 L/ha | 0.4 L/ac | |
| KORIL (235 g/L) | 1.2 L/ha | 0.48 L/ac | |
| atrazine | 1.01 kg/ha | | This combination can be applied as a sequential treatment with a preemergence grass herbicide or in fields without grass infestation. Only escaping grasses up to the 3-leaf stage are suppressed with this combination. |
| ATRAZINE 480 (480 g/L) | 2.1 L/ha | 0.84 L/ac | |
| AATREX NINE-O (90WG) | 1.12 kg/ha | 0.45 kg/ac | |
| plus pyridate | 0.45 kg/ha | | |
| LENTAGRAN (45 WP) | 1 kg/ha | 0.4 kg/ac | |
| atrazine | 1.01 to 1.49 kg/ha | | For increased activity and extended period of activity, apply in an oil water emulsion of 10 to 17 L/ha (4 to 6.8 L/ac) of emulsifiable light mineral oil and 150–200 L/ha water (60–80 L/ac).<br>Apply when most weeds have emerged. The low rate can be used successfully with later cultivation. |
| ATRAZINE 480 (480 g/L) | 2.1 to 3.1 L/ha | 0.84 to 1.24 L/ac | |
| ATRAZINE 90W (90WP) | 1.12 to 1.65 kg/ha | 0.45 to 0.66 kg/ac | |
| plus oil | 10 to 17 L/ha | 4 to 6.8 L/ac | |
| bentazon | 0.84 to 1.08 kg/ha | | No adjuvant is required to be used with BASAGRAN FORTE. Reduce oil concentrate to 1 L/ha (0.4 L/ac) under hot, humid weather conditions. Control is best when the broadleaves are small and actively growing. Grasses are **NOT** controlled.<br>Top growth of nut sedge and Canada thistle are controlled, and field bindweed may be suppressed by 2 applications of 1.75 L/ha (0.7 L/ac) (0.84 kg active/ha) applied 10 days apart.<br>Cool weather or drought may delay control. |
| BASAGRAN FORTE(480 g/L) | 1.75 to 2.25 L/ha | 0.7 to 0.9 L/ac | |
| or | | | |
| BASAGRAN (480 g/L) | 1.75 to 2.25 L/ha | 0.7 to 0.9 L/ac | |
| plus oil concentrate | | | |
| ASSIST | 2 L/ha | 0.8 L/ac | |

# SWEET CORN

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| bentazon/ atrazine<br>LADDOK ((1:1) 400 g/L)<br>plus oil concentrate<br>ASSIST | 0.8 to 1.6 kg/ha<br>2 to 4 L/ha<br><br>2 L/ha | <br>0.8 to 1.6 L/ac<br><br>0.8 L/ac | The recommended rate of 1.2 to 1.6 kg/ha of LADDOK (3 to 4 L/ha) (1.2 to 1.6 L/ac) may be reduced to 0.8 to 1 kg/ha (2 to 2.5 L/ha (0.8 to 1 L/ac) LADDOK) if metolachlor has been applied at the recommended rate for preemergence grass control. Use LADDOK at 3 to 4 L/ha (1.2 to 1.6 L/ac) for nut sedge control; repeat after 7 to 10 days if necessary. |
| bromoxynil<br>PARDNER (280 g/L)<br>KORIL (235 g/L) | 0.28 to 0.34 kg/ha<br>1 to 1.2 L/ha<br>1.2 to 1.4 L/ha | <br>0.4 to 0.48 L/ac<br>0.48 to 0.56 L/ac | Controls most annual broadleaf weeds, including triazine-resistant species at the 1- to 4-leaf stage.<br>PARDNER and KORIL are contact herbicides and are non-volatile. |
| **Postemergence Grass and Broadleaf Herbicides** | | | |
| cyanazine<br>BLADEX 90 DF (90 DF) | 2.25 kg/ha<br>2.5 kg/ha | <br>1 kg/ac | Use **ONLY** the dry flowable formulation, as the suspension may cause corn burning.<br>Corn injury may occur during cold weather and under flooding conditions.<br>**Do NOT** treat corn beyond the 3-leaf stage.<br>**Do NOT** add oil or surfactants. |
| cyanazine<br>BLADEX 90 DF (90 DF)<br>plus atrazine<br>ATRAZINE 480 (480 g/L)<br>ATRAZINE 90W (90WP)<br>AATREX NINE-O (90WG) | 1.8 to 2.25 kg/ha<br>2 to 2.5 kg/ha<br>1.1 kg/ha<br>2.25 L/ha<br>1.22 kg/ha<br>1.22 kg/ha | <br>0.8 to 1 kg/ac<br><br>0.92 L/ac<br>0.49 kg/ac<br>0.49 kg/ac | Use **ONLY** the dry flowable formulation of BLADEX.<br>Excellent control of annual weeds can be obtained if applied before grasses reach the 2-leaf stage.<br>Use this triazine mixture where barnyard grass may be a problem. Use the low rate on coarse-textured soils.<br>Corn injury may occur during cold weather and under flooding.<br>**Do NOT** treat corn beyond the 3-leaf stage.<br>**Do NOT** add oil or surfactants. |
| s-metolachlor/benoxacor<br>DUAL II MAGNUM (915 g/L)<br>plus atrazine<br>ATRAZINE 480 (480 g/L)<br>AATREX NINE-O (90WG)<br>or<br>s-metolachlor/benoxacor/atrazine<br>PRIMEXTRA II MAGNUM ((1:0.8) 720 g/L) | 1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha<br>1.01 to 1.49 kg/ha<br>2.1 to 3.1 L/ha<br>1.12 to 1.65 kg/ha<br><br>2.16 to 2.88 kg/ha<br>3 to 4 L/ha | <br>0.5 to 0.7 L/ac<br><br>0.84 to 1.24 L/ac<br>0.45 to 0.66 kg/ac<br><br><br>1.2 to 1.6 L/ac | Apply when the corn is in the spike to 6-leaf stage.<br>High rates should be used for heavy grass infestation areas and for fall panicum control.<br>**Do NOT** add oil or surfactants to this mixture. |
| **Directed Postemergence** | | | |
| linuron<br>AFOLAN F (480 g/L)<br>LOROX DF (50 DF)<br>LINURON 480 (480 g/L) | 1.1 to 2.25 kg/ha<br>2.3 to 4.7 L/ha<br>2.2 to 4.5 kg/ha<br>2.4 to 4.5 L/ha | <br>0.92 to 1.88 L/ac<br>0.88 to 1.8 kg/ac<br>0.96 to 1.8 L/ac | Apply in oil water emulsion as directed spray at low pressure with drop nozzles after corn is 30 cm or more in height.<br>The spray must be placed under the corn leaves but on the weeds. Use this treatment as a rescue from weeds escaping a previous treatment and for nut sedge or horsetail top growth burn-down.<br>**Do not** apply linuron after corn is beginning to tassel. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Spot Treatment** | | | |
| glyphosate[1]<br>glyphosate (360 g/L) | 1.71 to 2.52 kg/ha<br>4.75 to 7 L/ha | 1.9 to 2.8 L/ac | Apply after Canada thistle has started flowering. Quackgrass should be actively growing.<br>Corn will be killed in the areas sprayed and may be damaged by spray drift in adjacent areas. Knapsack application of 100 mL of glyphosate[1] product in 5 L of water applied to thoroughly wet the foliage, but not to run-off, is suggested for small areas to reduce drift and area of corn killed.<br>**Do NOT** apply after corn has started to silk. |
| glyphosate[1]<br>glyphosate (360 g/L) | 2.52 to 4.32 kg/ha<br>7 to 12 L/ha | 2.8 to 4.8 L/ac | Apply after field bindweed has reached full flowering or milkweed has reached the bud stage. Quackgrass should be actively growing.<br>Corn will be killed in the areas sprayed and may be damaged by spray drift in adjacent areas. Knapsack application of 100 mL of glyphosate[1] product in 5 L of water applied to thoroughly wet the foliage, but not to run-off, is suggested for small areas to reduce drift and area of corn killed.<br>**Do NOT** apply after corn has started to silk. |

[1] Various formulations available. See Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271. See label for specific uses and rates.

## Corn Leaf Stages

Counting the leaves on a corn plant sounds like an easy task, but there are a few complications that can cause you to miscount. It is important when reading labels or other information to know which leaf counting method they are referring to.

There are several methods of counting leaves. The "leaf tip method" counts all leaves including any leaf tip that has emerged from the whorl at the top of the plant. The "leaf collar method" only counts those leaves that are fully emerged and have the leaf collar showing. The leaf collar is a light green band that separates the leaf blade and leaf sheath that wraps around the stem. In some states, they refer to corn growth stages as V1, V2, V3, etc., where a V3 stage is a plant with 3 collars showing.

In this publication, we are counting leaves that have emerged from the whorl and the leaf tip is starting to arch over (the "leaf-over method"). This normally occurs when leaves are about 50% emerged. Most product labels also refer to this method of leaf counting, but check the label or with the product representative to be sure. See **Figure 7–1, *Stages of Corn Leaf Development (Leaf-Over Method)*, on page 256.**

**Table 7–10, *Comparative Growth Stages of Corn*, on page 256,** gives a comparison of the count methods.

Another complication with leaf counting is that we start with the bottom leaf, known as the first leaf. The first leaf is shorter than other leaves and has a round leaf tip. However, as the plant grows, the bottom leaves start to die and drop to the ground. A 10-leaf corn plant may have one to three leaves that have died. These leaves may not be immediately apparent, and care must be taken to count them.

**Hint:** Start counting from the bottom leaf, and check the first leaf to look for the rounded leaf tip.

It takes about 75–80 crop heat units (CHUs) to produce each corn leaf. Therefore at temperatures of 30°C day, and 20°C at night, there is one new leaf every 2–3 days; and at 20°C day, and 10°C at night, one new leaf every 5–6 days.

**Critical Stage: The Critical Stage to control weeds in corn is the 2–8 leaf-over stage (3–10 leaf tips).**

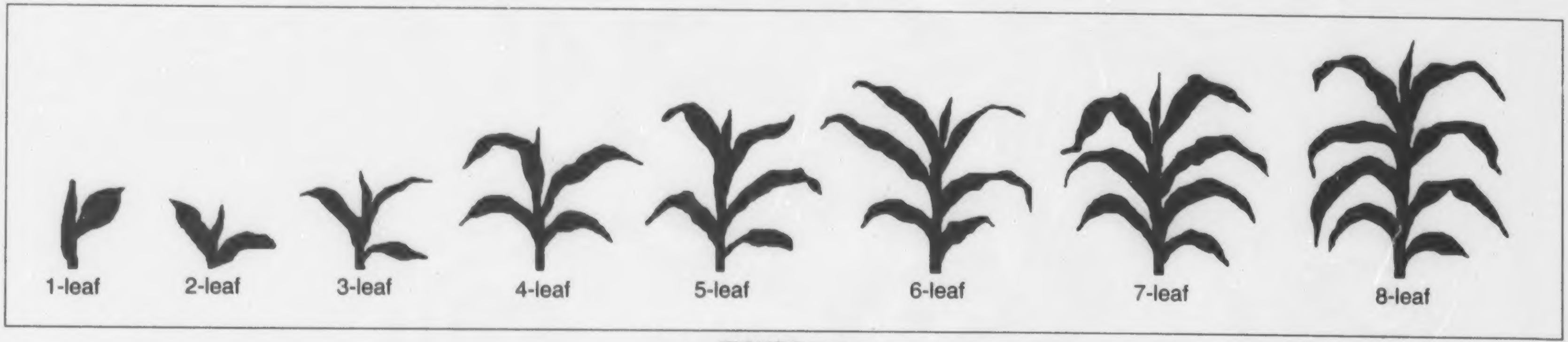


**FIGURE 7–1.**
**Stages of Corn Leaf Development (Leaf-Over Method)**

Some product labels also use plant height to indicate crop growth stages. In general, plant height is more variable depending on plant genetics and on the weather of the season. Table 7–10, *Comparative Growth Stages of Corn*, right, gives some comparative heights for each leaf stage, but your plants may be slightly more or less than the stage given, depending on genetics and weather. The standing height is measured from the ground surface to the top of the plant as it stands. "Leaf extended" refers to the height of the plant with the leaves pulled up to their full height.

**Table 7–10. Comparative Growth Stages of Corn**

| Leaf Over | Collars | Leaf Tips | Standing Height (cm) | Leaf Extended (cm) |
|---|---|---|---|---|
| 2 | 1 | 3 | 5–6 | 5–11 |
| 4 | 3 | 5–6 | 9–17 | 16–25 |
| 6 | 4–5 | 7–8 | 18–33 | 29–46 |
| 8 | 5–6 | 9–10 | 36–54 | 54–77 |
| 10 | 8 | 12 | 58–85 | 86–112 |
| 12 | 10 | 14–15 | 99–114 | 121–149 |

## Table 7–11.

## Sweet Corn Herbicide Weed Control Ratings

Notes: Weed control ratings are given as 0–9 where 0 indicates no control and 9 indicates 90%–100% control under ideal conditions.
Ratings are subjective values based on best available information and give general comparisons based on use as described in this publication.
Crop tolerance ratings are E = Excellent, G = Good, F = Fair, P = Poor.
Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated.
Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.
Ratings in BOLD indicate the weed is listed on the product label for control or suppression.
Please see product label for more information on registered weed species, product uses and precautions.

| | Crop | | | | | | | | | | | Annual Broadleaves | | | | | | | | | | | | Perennials | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trade Name** | **Seed Corn** | **Sweet Corn** | **Field Corn** | **Barnyard Grass** | **Crabgrass** | **Fall Panicum** | **Foxtail, Giant** | **Foxtail, Green** | **Foxtail, Yellow** | **Old Witch Grass** | **Proso Millet** | **Buckwheat, Wild** | **Cocklebur** | **Corn Spurry** | **Fleabane, Canada** | **Lady's-Thumb** | **Lamb's-Quarters** | **Mustards** | **Nightshades** | **Pigweeds** | **Ragweed, Common** | **Ragweed, Giant** | **Velvetleaf** | **Bindweed, Field** | **Horsetail** | **Milkweed** | **Nut Sedge** | **Quackgrass** | **Sow-Thistle** | **Thistle, Canada** | **Crop Tolerance** |
| **Soil-Applied Grass Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DUAL II MAGNUM | ✓ | ✓ | ✓ | **9** | **9** | **8/9**[1] | **8** | **9** | **9** | **9** | 4 | 2 | 2 | 2 | ? | 2 | 7 | 2 | **8/9**[2] | **7/8** | 4 | 3 | 3 | 0 | 0 | 0 | **8/9**[3] | 0 | 0 | 0 | E |
| ERADICANE | | ✓ | ✓ | **9** | **9** | **8** | 8 | **9** | **9** | **9** | 7 | 2 | 4 | **8** | ? | 7 | 8 | 2 | 8 | **7** | 7 | ? | 4 | 2 | 7 | 0 | **8**[1] | **2**[1] | 2 | 2 | E |
| FRONTIER | ✓ | ✓ | ✓ | **9** | **9** | **8/9**[1] | **8** | **9** | **9** | **9** | 4 | 2 | 2 | 2 | ? | 2 | 7 | 2 | **8/9**[2] | **7/8** | 4 | 3 | 3 | 0 | 0 | 0 | **8/9**[3] | 0 | 0 | 0 | E |
| **Soil-Applied Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AFOLAN F | | ✓ | ✓ | **7** | **7** | **7** | **7** | **7** | **7** | **7** | 2 | **9** | 5 | **?** | ? | **9** | **9** | **9** | 8 | **9** | **8** | ? | **5** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | G |
| atrazine[4] | ✓ | ✓ | ✓ | 7 | 4 | 4 | 7 | 7 | 7 | 7 | 2 | **9** | 7 | **9** | ? | **9** | **9** | 9 | 9 | **9** | **9** | ? | 5 | 2 | 0 | 0 | 0 | 2 | 2 | 0 | E |
| BLADEX | ✓ | ✓ | ✓ | **7** | **9** | **8** | **7** | **7** | **7** | **9** | 2 | **8** | 7 | ? | ? | **8** | **9** | **9** | **9** | **7** | **8** | ? | **5** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E |
| PRINCEP NINE-T, SIMADEX, SIMAZINE 480 | ✓ | ✓ | ✓ | **9** | **8** | 7 | **9** | **9** | **9** | **9** | 2 | **9** | 7 | 9 | ? | **9** | **9** | 9 | 9 | 9 | **8** | ? | 5 | 2 | 0 | 0 | 5 | 5 | 2 | 2 | E |
| **Soil-Applied Grass and Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PRIMEXTRA II MAGNUM | ✓ | ✓ | ✓ | **9** | **9** | **8/9**[1] | **8** | **9** | **9** | **9** | 2 | **9** | 7 | 9 | ? | **9** | **9** | **9** | **9** | **9** | **9** | ? | 7 | 0 | 0 | 0 | **8/9**[3] | 0 | 0 | 0 | E |
| **Soil-Applied Tank-Mixes** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BLADEX + atrazine[4] | ✓ | ✓ | ✓ | 7 | **9** | **8** | **7** | **7** | **7** | 9 | 2 | **9** | 7 | **9** | ? | **9** | **9** | **9** | **9** | **9** | **9** | ? | 5 | 2 | 0 | 0 | 0 | 2 | 2 | 0 | E |
| DUAL II MAGNUM + AFOLAN F + AATREX NINE-O | | ✓ | | **9** | **9** | **8/9**[1] | **8** | **9** | **9** | **9** | 2 | **9** | 7 | 9 | ? | **9** | **9** | **9** | **9** | **9** | **9** | ? | 7 | 0 | 0 | 0 | **8/9**[3] | 0 | 0 | 0 | E |
| ERADICANE + atrazine[4] | | ✓ | ✓ | **9** | **9** | **8** | **8** | **9** | **9** | **9** | 7 | **9** | 7 | **9** | ? | **9** | **9** | 9 | 9 | **9** | **9** | ? | 5 | 2 | 7 | 0 | **8**[1] | **2**[1] | 2 | 2 | E |
| ERADICANE + BLADEX | | ✓ | ✓ | **9** | **9** | **8** | **8** | **9** | **9** | **9** | 7 | **8** | 7 | **8** | ? | **8** | **9** | **9** | **9** | **7** | **8** | ? | **5** | 2 | 7 | 0 | **8**[1] | **2**[1] | 2 | 2 | E |
| FRONTIER + atrazine[4] | | ✓ | ✓ | **9** | **9** | **8/9**[1] | **8** | **9** | **9** | **9** | 4 | **9** | 7 | **9** | ? | **9** | **9** | 9 | 9 | **9** | **9** | ? | 5 | 2 | 0 | 0 | **8/9**[3] | 2 | 2 | 0 | E |
| **Postemergence Grass Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DUAL II MAGNUM | ✓ | ✓ | ✓ | **9** | **9** | **8/9**[1] | **8** | **8** | **8** | **9** | 2 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | **8** | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E |
| ACCENT[5] | ✓ | ✓[5] | ✓ | **9** | 5 | **9** | **9** | **9** | **8** | **9** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **9** | 0 | 0 | E[5] |

## Table 7–11.

## Sweet Corn Herbicide Weed Control Ratings (Continued)

Notes: Weed control ratings are given as 0–9 where 0 indicates no control and 9 indicates 90%–100% control under ideal conditions.
Ratings are subjective values based on best available information and give general comparisons based on use as described in this publication.
Crop tolerance ratings are E = Excellent, G = Good, F = Fair, P = Poor.
Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated.
Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.
Ratings in BOLD indicate the weed is listed on the product label for control or suppression.
Please see product label for more information on registered weed species, product uses and precautions.

| | Crop | | | | | | | | | | | Annual Broadleaves | | | | | | | | | | | | Perennials | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trade Name** | **Seed Corn** | **Sweet Corn** | **Field Corn** | **Barnyard Grass** | **Crabgrass** | **Fall Panicum** | **Foxtail, Giant** | **Foxtail, Green** | **Foxtail, Yellow** | **Old Witch Grass** | **Proso Millet** | **Buckwheat, Wild** | **Cocklebur** | **Corn Spurry** | **Fleabane, Canada** | **Lady's-Thumb** | **Lamb's-Quarters** | **Mustards** | **Nightshades** | **Pigweeds** | **Ragweed, Common** | **Ragweed, Giant** | **Velvetleaf** | **Bindweed, Field** | **Horsetail** | **Milkweed** | **Nut Sedge** | **Quackgrass** | **Sow-Thistle** | **Thistle, Canada** | **Crop Tolerance** |
| **Postemergence Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| atrazine[4] + LENTAGRAN | ✓ | | ✓ | 7 | 2 | 0 | 7 | 7 | 7 | 7 | 2 | **7** | ? | ? | ? | **7** | **9** | **8** | **9** | **9** | **9** | ? | **8** | ? | ? | ? | ? | ? | ? | ? | E |
| atrazine[4] + oil | ✓ | ✓ | ✓ | 7 | 2 | 0 | 7 | 7 | 7 | 7 | 2 | **9** | 7 | 9 | ? | **9** | **9** | **9** | 9 | **9** | **9** | ? | 7 | 7 | 5 | 2 | 5 | 5 | 7 | 2 | G |
| BASAGRAN FORTE | ✓ | ✓ | ✓ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | **9** | **9** | 5 | **9** | **8** | **9** | 7 | **8** | **8** | ? | **9** | **6** | 0 | 0 | **8** | 0 | 6 | **8** | E |
| KORIL | | ✓ | ✓ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **9** | **8** | ? | ? | **9** | **9** | **8** | **9** | **8** | **9** | ? | **9** | 7 | 0 | 0 | 0 | 0 | 7 | 7 | E |
| LADDOK | ✓ | ✓ | ✓ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **9** | **9** | **9** | ? | **9** | **9** | **9** | **9** | **9** | **9** | ? | **9** | 7 | 0 | 0 | **8** | 0 | 7 | 7 | E |
| PARDNER | ✓ | ✓ | ✓ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **9** | **8** | ? | ? | **9** | **9** | **8** | **9** | **8** | **9** | ? | **9** | 7 | 0 | 0 | 0 | 0 | 7 | 7 | E |
| **Postemergence Grass and Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BLADEX | ✓ | ✓ | ✓ | 7 | **9** | **8** | **6** | **6** | **6** | **9** | 5 | **8** | 8 | ? | ? | **8** | **9** | 9 | **9** | **7** | **9** | ? | 8 | 2 | 2 | 0 | 0 | 0 | 2 | 2 | E |
| PRIMEXTRA II MAGNUM | ✓ | ✓ | ✓ | **9** | **9** | **8/9**[1] | **8** | **8** | **8** | **9** | 2 | **9** | 7 | **9** | ? | **9** | **9** | **9** | **9** | **9** | **9** | ? | 7 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | E |
| **Postemergence Tank Mixes** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| atrazine[4] + KORIL | | ✓ | ✓ | 7 | 2 | 0 | 7 | 7 | 7 | 7 | 2 | **9** | **8** | 9 | 7 | **9** | **9** | **9** | **9** | **9** | **9** | ? | **9** | 7 | 5 | 2 | 5 | 5 | 7 | 2 | E |
| atrazine[4] + PARDNER | ✓ | ✓ | ✓ | 7 | 2 | 0 | 7 | 7 | 7 | 7 | 2 | **9** | **8** | 9 | 7 | **9** | **9** | **9** | **9** | **9** | **9** | ? | **9** | 7 | 5 | 2 | 5 | 5 | 7 | 2 | E |
| BLADEX + atrazine[4] | ✓ | ✓ | ✓ | 7 | **9** | **8** | **6** | **6** | **6** | **9** | 5 | **9** | 8 | 9 | ? | **9** | **9** | 9 | **9** | **9** | **9** | ? | 8 | 2 | 5 | 2 | 5 | 5 | 7 | 2 | E |
| **Directed Postemergence** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AFOLAN F, LINURON 480, LOROX | | ✓ | ✓ | **9** | 7 | **9** | **8** | **8** | **8** | **9** | 8 | **9** | 9 | **9** | ? | **9** | **9** | **9** | 9 | **9** | **9** | ? | **9** | 7 | **8** | 7 | **8** | 7 | 8 | 7 | G |

? = Insufficient information available to make a rating.

---

[1] Use the high rate of herbicide for optimum control.

[2] Use PRE timing for optimum control.

[3] Use PPI timing for optimum control.

[4] Various formulations available, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.

[5] Use only on selected sweet corn varieties. See "Precautions" for tolerant varieties on label.

# SWEET POTATOES

### Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

### Sweet Potatoes — Postemergence Grass Herbicides

**POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology.

| **Active Ingredient**<br>**TRADE NAME (Formulation)** | **RATE (active) PRODUCT PER HA** | **RATE PRODUCT PER ACRE** | **PRECAUTIONS**<br>**(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.)** |
|---|---|---|---|
| sethoxydim | 0.15 to 0.5 kg/ha | | Apply to actively growing grasses. |
| POAST ULTRA (450 g/L) | 0.32 to 1.1 L/ha | 0.13 to 0.45 L/ac | Apply using 110 to 200 L/ha (44 to 80 L/ac) water volume. |
| plus surfactant/solvent | | | For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage. |
| MERGE | 1.0 to 2.0 L/ha | 0.4 to 0.8 L/ac | For volunteer grains, use 0.47 L/ha (0.19 L/ac). |
| | | | For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass. |
| | | | **Do NOT** apply closer than 30 days to harvest. |

# TOMATOES (TRANSPLANTED)

Weed control in tomatoes usually consists of a combination of chemical weed control and cultivation. Crop rotation is also beneficial in the control of weeds. Cultivation should be shallow to prevent bringing untreated soil to the surface, which may result in another flush of weeds. When tomatoes are grown on raised beds and beds are reshaped during the course of the season, it may be necessary or useful to apply another herbicide treatment to areas between the rows to prevent a new weed infestation from interfering with harvesting. Do not exceed the total recommended rate per season of any herbicide applied more than once per year. Band treatment of herbicides over the row will reduce the cost by one-half to two-thirds, depending on the width of the band compared to the row spacing. Shallow inter-row cultivation will be required for weed control between the rows.

Perennial weeds may be partially controlled by cultivation. Controlling them in crops other than tomatoes when grown in rotation is the best approach to perennial weed control. Perennials are easily spread with cultivators or tillage equipment. Till areas of perennial weeds last. Machinery sanitation is important when moving from between fields.

### Site Preparation Before Planting — See *Preplant-Site Preparation Prior to Any Crop*, on page 194.

All treatments should be applied in 150 to 300 L/ha (60 to 120 L/ac) water unless otherwise specified.

**PREPLANT INCORPORATED (PPI)** Two incorporations at right angles operating at a depth of 10 cm using a double disk (7 to 10 km/h) or vibrating shank S-tine cultivator (10 to 13 km/h) are required unless otherwise stated. Cultivation-type equipment used for herbicide incorporation is known to spread perennial weeds to previously uninfested areas. Special attention should be directed toward machinery cleanliness and/or treating fields with perennial weeds last.

# TOMATOES (TRANSPLANTED)

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| **Tomatoes (Transplanted) — Soil-Applied Grass Herbicides** | | | |
| s-metolachlor<br>DUAL MAGNUM (915 g/L) | 1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha | 0.5 to 0.7 L/ac | Apply PPI. Incorporate shallowly to maintain spatial separation between herbicide-treated zone and developing tomato roots.<br>Use **ONLY** on transplant tomatoes grown for processing.<br>**Do NOT** use on muck, peat, high organic matter soils.<br>**Do NOT** use on soils with less than 1% organic matter.<br>Use the higher rate for heavier weed populations, Eastern black nightshade and yellow nut sedge. |
| trifluralin<br>TREFLAN EC (480 g/L)<br>RIVAL EC (500 g/L)<br>BONANZA 400 (400 g/L) | 0.6 to 1.105 kg/ha<br>1.25 to 2.3 L/ha<br>1.2 to 2.2 L/ha<br>1.5 to 2.75 L/ha | 0.5 to 0.92 L/ac<br>0.48 to 0.88 L/ac<br>0.6 to 1.1 L/ac | Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide-treated zone and developing transplant roots.<br>Use **ONLY** on transplant tomatoes grown for processing.<br>Cool, wet weather may delay transplant establishment, but yield is not usually affected.<br>**Do NOT** apply to peat or muck soils (>15% organic matter).<br>**Do NOT** apply to soils with less than 2% organic matter.<br>**Do NOT** apply to fields spread with manure within the last 12 months.<br>**Do NOT** apply by air. |
| **Tomatoes (Transplanted) — Soil-Applied Grass and Broadleaf Herbicides** | | | |
| napropamide<br>DEVRINOL DF (50 DF) | 1.12 to 2.25 kg/ha<br>2.25 to 4.5 kg/ha | 0.9 to 1.8 kg/ac | Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide-treated zone and developing transplant roots.<br>Registered for use on field-seeded and transplanted tomatoes.<br>Use the lower rates on light-textured soils.<br>**Do NOT** apply to soils with over 10% organic matter.<br>Damage to subsequent cover crops can be reduced by tillage across the rows after harvest. Small grains seeded in the fall may be stunted but not otherwise affected. |
| pebulate<br>TILLAM (720 g/L) | 4.5 to 6.66 kg/ha<br>6.25 to 9.25 L/ha | 2.8 to 3.7 L/ac | PPI – Apply to a dry soil surface before planting and incorporate.<br>Apply in 150 to 300 L water/ha.<br>Use lower rate on sandy soils.<br>**Do NOT** use under hotcaps. |

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT<br>PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| s-metolachlor<br>DUAL MAGNUM (915 g/L)<br>plus metribuzin<br>SENCOR 500 F (500 g/L) | 1.14 to 1.6 kg/ha<br>1.25 to 1.75 L/ha<br>0.25 to 0.7 kg/ha<br>0.5 to 1.4 L/ha | <br>0.5 to 0.7 L/ac<br><br>0.2 to 0.56 L/ac | Apply PPI. Incorporate shallowly to maintain spatial separation between herbicide-treated zone and developing transplant roots.<br>Use **ONLY** on transplant tomatoes grown for processing.<br>**Do NOT** use on muck, peat or high organic matter soils.<br>**Do NOT** use on soils with less than 2% organic matter.<br>Use the higher rate of DUAL MAGNUM for heavier weed populations, Eastern black nightshade and yellow nut sedge.<br>Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin.<br>**Do NOT** exceed total maximum rate of metribuzin recommended for your soil type. |
| trifluralin<br>TREFLAN EC (480 g/L)<br>plus s-metolachlor<br>DUAL MAGNUM (915 g/L)<br>plus metribuzin<br>SENCOR 500 F (500 g/L) | 0.528 to 1.008 kg/ha<br>1.1 to 2.1 L/ha<br>0.96 to 1.260 kg/ha<br>1.05 to 1.38 L/ha<br>0.25 to 0.5 kg/ha<br>0.5 to 1 L/ha | <br>0.44 to 0.84 L/ac<br><br>0.42 to 0.56 L/ac<br><br>0.2 to 0.4 L/ac | Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide-treated zone and developing transplant roots.<br>Use **ONLY** on transplant tomatoes grown for processing.<br>**Do NOT** use on muck, peat or high organic matter soils (>15% OM).<br>Use the lower rates on light-textured soils.<br>Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin.<br>**Do NOT** exceed total maximum rate of metribuzin recommended for your soil type.<br>Cool, wet weather may delay establishment, but yield is not usually affected.<br>For Eastern black nightshade, use the higher rate of DUAL MAGNUM.<br>Preharvest interval is 60 days. |
| trifluralin<br>TREFLAN EC (480 g/L)<br>RIVAL EC (500 g/L)<br>BONANZA 400 (400 g/L)<br>plus metribuzin<br>SENCOR 500 F (500 g/L)<br>LEXONE DF (75 DF)<br>EVICT SOLUPAK (75 DF) | 0.6 to 1.105 kg/ha<br>1.25 to 2.3 L/ha<br>1.2 to 2.2 L/ha<br>1.5 to 2.75 L/ha<br>0.25 to 0.7 kg/ha<br>0.5 to 1.4 L/ha<br>0.32 to 0.93 kg/ha<br>0.33-0.67 kg/ha | <br>0.5 to 0.92 L/ac<br>0.48 to 0.88 L/ac<br>0.6 to 1.1 L/ac<br><br>0.2 to 0.56 L/ac<br>0.13 to 0.37 kg/ac<br>0.13-0.24 kg/ac | Apply PPI. Incorporate within 24 hours of application. Incorporate shallowly to maintain spatial separation between herbicide-treated zone and developing transplant roots.<br>Use **ONLY** on transplant tomatoes grown for processing.<br>**Do NOT** apply to peat or muck soils (>15% organic matter).<br>**Do NOT** apply to soils with less than 2% organic matter.<br>**Do NOT** apply to fields spread with manure within the last 12 months.<br>Use lower rates on sandy soils or soils with low organic matter.<br>Use lower rate of metribuzin and repeat applications of metribuzin when crop is established as described under postemergence application of metribuzin.<br>**Do NOT** exceed total maximum rate of metribuzin recommended for your soil type.<br>Cool, wet weather may delay establishment, but yield is not usually affected. |

# TOMATOES (TRANSPLANTED)

| Active Ingredient<br>TRADE NAME (Formulation) | RATE (active)<br>PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS<br>(For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| **Tomatoes (Transplanted) — Postemergence Grass Herbicides** | | | |
| **POSTEMERGENCE** Leaf stage of the weeds is critical for good weed control. Smaller weeds are generally easier to kill, but there must be enough leaf surface to intercept the herbicide. Apply according to recommended leaf stages. Crop stage is important to optimize crop safety. Adjuvants will frequently improve the weed control when used as directed. Weather or other conditions may influence the optimum rate of adjuvant; see the product label for more details. Always use appropriate drift management technology. | | | |
| fenoxaprop-p-ethyl<br>EXCEL SUPER (80.5 g/L) | 0.054 kg/ha<br>0.67 L/ha | <br>0.27 L/ac | Apply POST when annual grasses are in the 1- to 6-leaf stage and volunteer corn is up to 25 cm tall.<br>Use **ONLY** on transplant tomatoes grown for processing.<br>Annual grasses emerging after application will not be controlled.<br>**Do NOT** apply other herbicides within 4 days of EXCEL SUPER application.<br>**Do NOT** apply by air.<br>**Do NOT** use flood jet nozzles or controlled droplet application equipment.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 55 days. |
| fluazifop-p-butyl<br>VENTURE L (125 g/L) | 0.075 to 0.25 kg/ha<br>0.6 to 2 L/ha | <br>0.24 to 0.8 L/ac | Apply POST to actively growing grasses before tillering.<br>Apply at 1 L/ha (0.4 L/ac) at 2- to 5-leaf stage of annual grasses (2- to 4-leaf for foxtails).<br>Apply at 0.8 L/ha (0.32 L/ac) at 2- to 5-leaf stage of volunteer wheat and barley.<br>Apply at 2 L/ha (0.8 L/ac) at 3- to 5-leaf stage of quackgrass and wirestem muhly. Thorough preplant tillage, fragmenting quackgrass rhizomes improves control.<br>Apply in a maximum volume of 300 L/ha (120 L/ac).<br>**Do NOT** cultivate for 5 days after application.<br>**Do NOT** apply other herbicides within 3 days of VENTURE L application.<br>**Do NOT** apply if rain is expected within 2 hours after application.<br>Preharvest interval is 60 days. |
| sethoxydim<br>POAST ULTRA (450 g/L)<br>surfactant/solvent<br>MERGE | 0.15 to 0.5 kg/ha<br>0.32 to 1.1 L/ha<br><br>1 to 2 L/ha | <br>0.13 to 0.45 L/ac<br><br>0.4 to 0.8 L/ac | Apply POST to actively growing grasses.<br>For annual grass, use 0.32 L/ha (0.13 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For volunteer grains, use 0.47 L/ha (0.19 L/ac). Apply at the 1- to 6-leaf stage (2- to 5-leaf is optimum).<br>For quackgrass, use 1.1 L/ha (0.45 L/ac). Apply up to the 3-leaf stage. Thorough preplant tillage will ensure more uniform quackgrass emergence. Cultivate after 7 days in wide row crops. Use the high rate of MERGE for quackgrass.<br>Use 100 to 200 L water/ha (40 to 80 L water/ac).<br>Grasses emerging after application will not be controlled.<br>**Do NOT** apply any other chemicals within 4 days of POAST ULTRA application.<br>Spray tips angled forward 45° will give better coverage.<br>**Do NOT** use flood jet or hollow cone nozzles.<br>**Do NOT** apply if rain is expected within 1 hour after application.<br>Preharvest interval is 60 days. |

| Active Ingredient TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| **Tomatoes (Transplanted) — Postemergent Grass and Broadleaf Herbicides** | | | |
| metribuzin | 0.25 to 0.85 kg/ha | | Apply POST at least 3 weeks after transplanting, before weeds exceed 4 cm in height. |
| LEXONE DF (75 DF) | 0.32 to 1.1 kg/ha | 0.13 to 0.44 kg/ac | Use **ONLY** on transplant tomatoes grown for processing. |
| SENCOR 75 DF (75 WG) | 0.32 to 1.1 kg/ha | 0.13 to 0.44 kg/ac | Apply **ONLY** once per season. |
| EVICT SOLUPAK (75 DF) | 0.375 to 0.67 kg/ha | 0.15 to 0.27 kg/ha | Direct spray to bottom one-third of tomato plants to reduce risk of crop injury. |
| | | | **Do NOT** apply when crop is under stress due to cool, wet, cloudy weather or excessively hot temperatures. |
| | | | **Do NOT** use on muck soils. |
| | | | **Do NOT** use on soils with less than 2% organic matter. |
| | | | Use lower rates on sandy soils, higher rates on clay soils. |
| | | | Preharvest interval is 60 days. |
| metribuzin | 0.15 kg/ha | | Apply 1 to 4 POST applications per season. |
| SENCOR 500 F (500 g/L) | 0.3 L/ha | 0.12 L/ac | Apply before the weeds are 2.5 cm in height. |
| LEXONE DF (75 DF) | 0.2 kg/ha | 0.08 kg/ac | Use **ONLY** on transplant tomatoes grown for processing. |
| EVICT SOLUPAK (75 DF) | 0.2 kg/ha | 0.08 kg/ac | BRAVO 500 fungicide (chlorothalanil) may be tank-mixed with this treatment at 2.4 to 4.8 L/ha (1.2 to 2.4 kg/ha active). Control of annual grasses may be reduced. |
| | | | **Do NOT** apply when crop is under stress due to cool, wet, cloudy weather or excessively hot temperatures. |
| | | | **Do NOT** use on muck soils. |
| | | | **Do NOT** use on soils with less than 2% organic matter. |
| | | | **Do NOT** exceed the maximum total rate of metribuzin recommended for your soil. |
| | | | Preharvest interval is 30 days. |
| pyridate | 0.45 to 0.9 kg/ha | | Apply POST as a directed spray to the bottom third of well-established plants. |
| LENTAGRAN (45 WP) | 1 to 2 kg/ha | 0.4 to 0.8 kg/ac | **Do NOT** apply before tomato plants reach the 5-leaf stage. |
| plus metribuzin | 0.15 to 0.3 kg/ha | | **Do NOT** apply if tomato plants are under stress. |
| LEXONE DF (75 DF) | 0.2 to 0.4 kg/ha | 0.08 to 0.16 kg/ac | **Do NOT** apply as a POST broadcast application due to crop injury. |
| SENCOR 75 DF (75 WG) | 0.2 to 0.4 kg/ha | 0.08 to 0.16 kg/ac | Sprayed leaves may discolour temporarily, but yield will not be affected. |
| | | | **Do NOT** apply more than once per season. |
| | | | **Do NOT** use on muck soils. |
| | | | **Do NOT** use on soils with less than 2% organic matter. |
| | | | Preharvest interval is 45 days. |
| rimsulfuron | 15 g/ha | | Apply POST when hairy nightshade is up to the 4-leaf stage, quackgrass is in the 3- to 6-leaf stage (less than 10 cm tall), annual grasses are in the 1- to 6-leaf stage and redroot pigweed is at the 4- to 6-leaf stage. |
| PRISM (25DF) | 60 g/ha | 24 g/ac | |
| plus non-ionic surfactant | 0.2% v/v | 0.2% v/v | Apply **ONLY** once per year. |
| CITOWETT PLUS, AGRAL 90 or AG-SURF | 2 L/1,000 L water | 2 L/1,000 L water | **Do NOT** apply if rainfall is expected within 2 hours of application. |
| | | | Preharvest interval is 30 days. |

# VEGETABLE CONTROL RATINGS

## Table 7–12. Vegetable Herbicide Weed Control Ratings

Notes: Weed control ratings are given as 0–9 where 0 indicates no control and 9 indicates 90%–100% control under ideal conditions.
Ratings are subjective values based on best available information and give general comparisons based on use as described in this publication.
Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated.
Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.
Ratings in BOLD indicate the weed is listed on the product label for control or suppression.
Please see product label for more information on registered weed species, product uses and precautions.

| | Grasses | | | | | Annual Broadleaves | | | | | | | | Perennials | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trade Name** | **Barnyard Grass** | **Crabgrass** | **Fall Panicum** | **Foxtails** | **Old Witch Grass** | **Buckwheat, Wild** | **Lady's-Thumb** | **Lamb's-Quarters** | **Mustards** | **Nightshades** | **Pigweeds** | **Ragweed** | **Velvetleaf** | **Bindweed, Field** | **Horsetail** | **Milkweed** | **Nut Sedge** | **Quackgrass** | **Sow-thistle** | **Thistle, Canada** |
| **Soil-Applied Grass Herbicides** | | | | | | | | | | | | | | | | | | | | |
| RO-NEET | **8** | **8** | 6 | **8** | 8 | ? | ? | **7** | 5 | **7** | **8** | ? | ? | ? | ? | ? | **6** | ? | ? | ? |
| EPTAM | **9** | **9** | **9** | **9** | **9** | 4 | 7 | **7** | 5 | 7 | **7** | 5 | 5 | ? | ? | ? | **8** | **5** | ? | ? |
| DEVRINOL | **8** | **9** | **8** | 8 | 8 | 5 | 6 | **8** | 5 | 5 | **8** | **7** | 5 | 5 | 5 | 5 | 6 | 5 | 5 | 5 |
| PROWL | **9** | **8** | 9 | **8** | ? | ? | 6 | **9** | ? | 8 | **8** | 2 | 6 | ? | ? | ? | ? | ? | ? | ? |
| DUAL MAGNUM | **9** | **9** | **9** | **9** | **9** | 2 | 2 | 7 | 2 | **8** | **7/8** | 4 | 2 | 0 | 0 | 0 | **8** | 4 | 0 | 0 |
| AVADEX | 5 | ? | ? | 5 | 5 | 5 | 5 | 5 | 5 | ? | 5 | 5 | ? | 5 | ? | ? | ? | ? | 5 | 5 |
| **Soil-Applied Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | |
| LOROX, AFOLAN or LINURON 480 | **7** | **5** | **5** | **7** | **7** | **8** | **9** | **9** | **9** | 8 | **9** | **8** | **6** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| PATORAN | **5** | **5** | 5 | **5** | **5** | 8 | **9** | **9** | **9** | **7** | **9** | **8** | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| SENCOR, LEXONE or EVICT | **7** | **6** | **7** | **8** | **8** | 7 | **9** | **9** | **9** | 3 | **9** | **8** | **8** | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| AFESIN | **5** | **5** | 5 | **5** | 5 | **8** | 9 | **9** | 9 | **7** | **9** | **8** | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| GESAGARD | ? | ? | ? | **9** | ? | ? | **8** | **9** | **8** | **8** | **8** | 6 | ? | ? | ? | ? | ? | ? | ? | ? |
| PYRAMIN | **5** | **5** | 5 | **5** | 5 | **8** | **8** | **8** | 8 | **8** | **8** | **8** | 6 | 5 | 5 | ? | 5 | 5 | 5 | 5 |
| **Soil-Applied Grass and Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | |
| KARMEX | 9 | **8** | 7 | **8** | ? | 8 | 8 | **9** | 8 | 7 | **8** | **9** | ? | ? | 5 | ? | 5 | 5 | 5 | 5 |
| SINBAR | **8** | **7** | 8 | **8** | 8 | ? | 7 | **8** | **8** | 7 | **7** | **7** | 7 | ? | 5 | 6 | 6 | 6 | ? | 6 |
| CIPC | 8 | 9 | 7 | 8 | 7 | 8 | 8 | 7 | 5 | ? | 7 | 5 | ? | ? | 5 | ? | ? | 5 | 5 | 5 |
| NORTRON SC | **7** | 6 | 7 | **7** | 7 | **8** | **8** | **8** | 8 | **7** | **8** | 8 | 7 | 5 | 5 | 5 | 6 | 5 | 5 | 5 |
| PURSUIT | **8** | 7 | 7 | **9** | 9 | 8 | **9** | **9** | **9** | **9** | **9** | **8** | **9** | ? | ? | ? | 7 | 5 | ? | ? |
| ALANAP | 5 | 7 | 5 | 7 | ? | 5 | 9 | 9 | 6 | 5 | 8 | 5 | ? | ? | 5 | ? | 5 | 5 | 5 | 5 |
| KERB | **8** | **8** | **8** | **8** | **8** | ? | 6 | 6 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PRINCEP NINE-T | **9** | **8** | 7 | **9** | **9** | **9** | **9** | **9** | 9 | 9 | 9 | **8** | 5 | 2 | 0 | 0 | 5 | 5 | 2 | 2 |
| TILLAM | **9** | **8** | 5 | **9** | 5 | ? | 2 | 2 | 2 | 2 | 5 | 2 | 2 | 0 | 5 | 0 | **8** | 0 | 0 | 0 |
| TREFLAN or RIVAL or BONANZA 400 | **9** | **9** | 9 | **9** | 9 | **5** | 7 | **8** | 2 | 2 | **8** | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Postemergence Grass Herbicides** | | | | | | | | | | | | | | | | | | | | |
| KERB | **8** | **8** | **6** | **8** | ? | ? | 0 | 0 | 0 | ? | 6 | 0 | 0 | 0 | 0 | 0 | 0 | **8** | 0 | 0 |
| SELECT | **9** | **8** | **9** | **8** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **7** | 0 | 0 |
| HOE-GRASS 284 | **8** | **5** | **8** | **8** | **8** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| EXCEL SUPER | **9** | **8** | **9** | **9** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| VENTURE L | **8** | **8** | **9** | **8** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **8** | 0 | 0 |
| POAST ULTRA | **9** | **8** | **9** | **9** | **9** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **6** | 0 | 0 |

## Table 7–12. Vegetable Herbicide Weed Control Ratings (Continued)

Notes: Weed control ratings are given as 0–9 where 0 indicates no control and 9 indicates 90%–100% control under ideal conditions.
Ratings are subjective values based on best available information and give general comparisons based on use as described in this publication.
Under unfavourable conditions (e.g., too dry, too wet, too cold or poor application), the herbicides may not be as effective as indicated.
Ratings may vary with weed and crop stage and with the timing and rates of the product(s) being used.
Ratings in BOLD indicate the weed is listed on the product label for control or suppression.
Please see product label for more information on registered weed species, product uses and precautions.

| | **Grasses** | | | | | **Annual Broadleaves** | | | | | | | | **Perennials** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Trade Name** | **Barnyard Grass** | **Crabgrass** | **Fall Panicum** | **Foxtails** | **Old Witch Grass** | **Buckwheat, Wild** | **Lady's-Thumb** | **Lamb's-Quarters** | **Mustards** | **Nightshades** | **Pigweeds** | **Ragweed** | **Velvetleaf** | **Bindweed, Field** | **Horsetail** | **Milkweed** | **Nut Sedge** | **Quackgrass** | **Sow-thistle** | **Thistle, Canada** |
| **Postemergence Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | |
| 2,4-D[2] | 0 | 0 | 0 | 0 | 0 | 7 | **7** | **9** | **9** | 7 | **9** | **9** | 9 | **7** | **0** | 0 | 0 | 0 | **8** | **8** |
| BASAGRAN FORTE | 0 | 0 | 0 | 0 | 0 | 7 | **9** | **8** | **9** | 7 | **8** | **8** | **9** | **6**[1] | 2 | 2 | **8**[1] | 0 | 6[1] | **7**[1] |
| PARDNER | 0 | 0 | 0 | 0 | 0 | **9** | **9** | **9** | **8** | **9** | **8** | **9** | **9** | 7 | 0 | 0 | 0 | 0 | 7 | 7 |
| LONTREL | 5 | 5 | 5 | 5 | 5 | **?** | 7 | 5 | ? | 5 | 5 | **8** | 5 | 5 | ? | ? | 5 | 5 | **7** | **7** |
| BETANEX | 5 | 5 | 5 | 5 | 5 | **5** | 6 | **7** | **7** | **6** | **9** | **9** | 5 | 5 | ? | ? | 5 | 5 | 5 | 5 |
| BETAMIX | 5 | 5 | 5 | **7** | 5 | **6** | 6 | **8** | **7** | **6** | **8** | **8** | 5 | 5 | ? | ? | 5 | 5 | 5 | 5 |
| herbicid | ? | ? | ? | ? | ? | ? | 6 | 7 | 7 | ? | 7 | 5 | ? | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| MCPA[2] | 0 | 0 | 0 | 0 | 0 | **4** | 0 | **9** | **9** | ? | **9** | **8** | **9** | 7 | **7** | 0 | 0 | 0 | **7** | **7** |
| GOAL 2XL | 5 | 5 | 5 | 5 | 5 | **9** | 8 | **8** | 9 | **9** | **9** | 8 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| PYRAMIN | **5** | 5 | ? | 5 | ? | **8** | **8** | **8** | **8** | **8** | **8** | **8** | ? | ? | 5 | ? | 5 | 5 | 5 | 5 |
| LENTAGRAN | ? | ? | ? | ? | ? | ? | ? | **8** | ? | ? | **8** | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| **Postemergence Grass and Broadleaf Herbicides** | | | | | | | | | | | | | | | | | | | | |
| LOROX, AFOLAN or LINURON 480 | **9** | **7** | 9 | **8** | **9** | **8** | **8** | **8** | 8 | 8 | **8** | **8** | **8** | 7 | 8 | 7 | 8 | 7 | 8 | 7 |
| SENCOR or LEXONE or EVICT | **8** | **7** | **9** | **8** | **9** | **7** | **9** | **8** | **9** | ? | **8** | **8** | **8** | ? | ? | ? | ? | 7 | ? | ? |
| SPIN-AID | 5 | 5 | 5 | **6** | 5 | **?** | 8 | **8** | **?** | 7 | 6 | 8 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| PRISM | **9** | 8 | **9** | **8**[3] | **9** | ? | 7 | **7** | 9 | 4[4] | **9** | 3 | 6 | ? | ? | ? | ? | **7** | ? | ? |
| **Post (Directed)** | | | | | | | | | | | | | | | | | | | | |
| LENTAGRAN + SENCOR or LEXONE | 6 | 5 | ? | 6 | ? | **7** | **7** | **9** | **8** | **9** | **9** | **9** | **8** | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Preharvest and Post-Harvest** | | | | | | | | | | | | | | | | | | | | |
| IGNITE | 9 | 9 | 9 | **9** | 9 | **?** | 9 | **9** | **9** | ? | **9** | 9 | 9 | 8[5] | 7[5] | 6[5] | 0 | 8[5] | ? | ? |

? = Insufficient information available to make a rating.

---

[1] Good control of these perennial weeds may require two applications of BASAGRAN + ASSIST oil concentrate about 7 to 10 days apart.

[2] Various formulations available, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.

[3] Yellow foxtail will only be suppressed.

[4] Registered for control of hairy nightshade

[5] Repeated applications may be necessary if regrowth occurs

# WATER WEEDS (AQUATIC PLANTS)

The *Pesticides Act*, Subsection 5(1), provides that: "*no person shall engage in, perform, or offer to perform an extermination except under and in accordance with a licence of a prescribed class . . . unless exempt under the regulations.*"

Therefore, a specific water exterminator's licence is required by anyone applying a pesticide to water in Ontario (unless exempt). For instance, the user of a herbicide to control aquatic plants in Ontario is required to hold an Aquatic Vegetation licence. The licensing system ensures that people are educated about the proper storage, handling and use of pesticides, and their impact on the environment. Furthermore, if the person is in the business of performing exterminations, an Operator's Licence is also required.

A person is exempt from holding an Aquatic Vegetation licence if using a pesticide to treat a water body for aquatic plants where the water body is located wholly within the boundaries of their property. The water body must have **no** direct or indirect outflow, other than by percolation. A full-time employee of the property owner is also exempt from requiring a licence.

Subsection 7(2) of the *Pesticides Act* provides that: "*no person shall perform a water extermination unless the person is the holder of a permit issued by the Director* [under the *Pesticides Act*] *for the water extermination or is exempt under the regulations.*"

Therefore, unless exempt, a **Permit to Purchase a Pesticide and/or Perform a Water Extermination** must be obtained before any aquatic pesticide can be legally purchased or applied into a water body (e.g., ponds, lakes, rivers, ditches, lagoons, catch basins, etc.) in Ontario. Exemptions include:

- A property owner or his or her full-time employee is not required to obtain a permit *to use* an aquatic herbicide in a water body, which has no direct or indirect outflow, other than by percolation, located wholly within the boundaries of his or her own property, or an aquatic herbicide in a drainage ditch that at the time of the extermination contains no moving water, but must hold a permit in order *to purchase* the pesticide.
- The holder of a grower certificate (certified agriculturist) is not required to obtain a permit *to purchase or to use* an aquatic herbicide in a water body, which has no direct or indirect outflow, other than by percolation, located wholly within the boundaries of his or her own farmland, or an aquatic herbicide in a drainage ditch located wholly within the boundaries of his or her own farmland that at the time of the extermination contains no moving water.
- An Aquatic Vegetation licence holder does **not** require a permit to purchase or to use a pesticide to control aquatic plants in a water body, which has no direct or indirect outflow, other than by percolation, located wholly within the boundaries of his or her own property, or to use an aquatic herbicide in a drainage ditch that at the time of the extermination contains no moving water.

A Limited vendor can sell a Schedule 3, 4 or 6 pesticide to a person who is exempt from holding a licence and/or a permit. A person must hold either an Aquatic Vegetation licence, a Grower Certificate or a permit to purchase a Schedule 2 product from a General vendor.

For further information on licensing and permits, contact the Ontario Ministry of the Environment and Energy Regional Office in your area.

# WATER WEEDS (AQUATIC PLANTS)

| ACTIVE INGREDIENT TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, ***Pesticides Used on Vegetable Crops in Ontario***, on page 271.) |
|---|---|---|---|
| **Algae and Vascular Submergents (e.g., *Chara*, Canada water weed, tapegrass, coontail, water milfoil, bladderwort, pondweed)** | | | |
| diquat (aquatic)<br>REWARD (240 g/L) | 4.4 to 7 kg/ha<br>18.3 to 29.2 L/ha | 7.4 to 11.8 L/ac | Mixed submerged vascular plants in ponds, ditches, lakes, river canals, slow-moving or still water. Tape grass and *Chara* are not controlled.<br>**Do NOT** use treated water for animal consumption or swimming for at least 24 hours.<br>**Do NOT** use for human consumption or irrigation for at least 5 days.<br>To avoid oxygen depletion, treat only one-quarter to one-third of the area at a time.<br>Rate depends on water depth:<br>• less than 1.5 m — use 18.3 L/ha (7.4 L/ac).<br>• more than 1.5 m — use 25 to 29.2 L/ha (10.1 to 11.8 L/ac).<br>Apply at dusk in mid-late June when plants are young and growing vigorously. |
| diquat(aquatic)<br>REWARD (240 g/L) | 2.2 kg/ha<br>9.2 L/ha | 3.7 L/ac | Eurasian water milfoil in lakes.<br>Treat when plants are in the very early stage of growth (June).<br>See "Precautions" in the entry for REWARD, above. |
| diuron<br>KARMEX DF 80% | 0.5 to 2 ppm diuron<br>or<br>6.25 to 25 kg/ha m | | Apply lower rates for algae, including filamentous algae such as *Chara*, control and higher rates for bladderwort and pondweed.<br>Apply early in season to surface of water using min. 450 L/ha of water and agitate. Calculate ha m = surface area in sq. m x depth in m/10,000.<br>Treat only a small portion of the pond at one time to avoid oxygen depletion and fish suffocation.<br>**Do NOT** use in domestic water supplies or water bodies producing fish for human consumption.<br>**Do NOT** irrigate with treated water for one year.<br>**Do NOT** apply to ponds or irrigation ditches having desirable trees or plants on the perimeter or to areas where their roots may extend, or in locations where the herbicide may be washed or moved in contact with the roots.<br>**Do NOT** drain ponds into areas containing desirable plants.<br>Not effective in flowing water. |
| 2,4-D (aquatic)<br>AQUA-KLEEN<br>(19% by wt) | 110–225 kg/ha | 44–90 L/ac | Milfoil, stargrass, bladderwort, eelgrass and coontail.<br>Do not use within 1 km of any active water intake.<br>Do not use water from treated area for consumption by humans or livestock or for irrigation of 2,4-D–sensitive crops, for at least 60 days after treatment in confined waterbodies.<br>Treat early in season when plant growth is sparse to avoid oxygen depletion and fish suffocation. |

# WATER WEEDS (AQUATIC PLANTS)

| ACTIVE INGREDIENT TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| water soluble dyes<br>AQUASHADE (26%) | 195 mL/1,000 $m^3$<br>750 mL/1,000 $m^3$ | | Filamentous algae, pond scums. For use in ponds with no outflow.<br>**Do NOT** apply to water that will be used for drinking or other domestic purposes.<br>Make application early in the growing season before algae and weed growth develop. Re-apply when the colour of water fades or first new algae growth develops.<br>Mechanically remove any heavy vegetation before applying AQUASHADE to avoid oxygen depletion and fish suffocation. |
| **Emergents (e.g, duckweed, water shield, water lily, bulrush, cattail)** | | | |
| amitrole<br>AMITROL 240 (231 g/L) | 9 to 11 kg/ha<br>37.5 to 45.75 L/ha | <br>15 to 18.3 L/ac | Cattails in non-crop areas (roadsides, fencerows, ditch banks, drainage ditches).<br>After catkins are fully formed and up to frost.<br>**Do NOT** disturb sprayed plant.<br>**Do NOT** apply where water will be used for irrigation, drinking or other domestic uses.<br>**Do NOT** apply where water is not wholly confined to user's property.<br>Apply at a spray volume of 1,000 L/ha (400 L/ac) water. |
| 2,4-D (aquatic)<br>AQUA-KLEEN<br>(19% by wt) | 110–225 kg/ha | 44–90 L/ac | For water lily and water shield, use 175–225 kg/ha.<br>**Do NOT** use within 1 km of any active water intake.<br>**Do NOT** use water from treated area for consumption by humans or livestock or for irrigation of 2,4-D sensitive crops, for at least 60 days after treatment in confined waterbodies.<br>Treat early in season when plant growth is sparse to avoid oxygen depletion and fish suffocation. |
| Diuron<br>KARMEX DF<br>(80%) | 0.5 to 2 ppm diuron<br>or<br>6.25 to 25 kg/ha m | | Apply higher rates for emergents such as duckweed.<br>Apply early in season to surface of water using min. 450 L/ha of water and agitate. Calculate ha m = surface area in sq. m **X** depth in m/10,000.<br>Treat only a small portion of the pond at one time to avoid oxygen depletion and fish suffocation.<br>**Do NOT** use in domestic water supplies or water bodies producing fish for human consumption.<br>**Do NOT** irrigate with treated water for 1 year.<br>**Do NOT** apply to ponds or irrigation ditches having desirable trees or plants on the perimeter or to areas where their roots may extend, or in locations where the herbicide may be washed or moved in contact with the roots.<br>**Do NOT** drain ponds into areas containing desirable plants.<br>Not effective in flowing water. |

| ACTIVE INGREDIENT TRADE NAME (Formulation) | RATE (active) PRODUCT PER HA | RATE PRODUCT PER ACRE | PRECAUTIONS (For more information, see Appendix A, *Pesticides Used on Vegetable Crops in Ontario*, on page 271.) |
|---|---|---|---|
| diquat (aquatic)<br>REWARD (240 g/L) | 4.4 to 7 kg/ha<br>18.3 to 29.2 L/ha | 7.4 to 11.8 L/ac | For duckweed.<br>Apply by directed surface spray on foliage.<br>Rate depends on water depth:<br>• less than 1.5 m — use 18.3 L/ha (7.4 L/ac).<br>• more than 1.5 m — use 25 to 29.2 L/ha (10.1 to 11.8 L/ac).<br>Use in 1,700 to 2,200 L/ha (680 to 880 L/ac) water.<br>See "Precautions" in entry for REWARD on page 267. |
| paraquat<br>GRAMOXONE<br>(200 g/L) | 1.1 to 2.2 kg/ha<br>5.5 to 11 L/ha | 2.2 to 4.4 L/ac | For cattails, bulrushes and emerged grasses.<br>**Do NOT** use treated water for 7 days for swimming, human or animal consumption.<br>**Do NOT** use for irrigation for 5 days.<br>**Do NOT** apply to muddy water or agitate water excessively for 1 to 2 days after treatment.<br>Treat cattails and bulrushes when plants are in flower.<br>Avoid inhalation of spray mist; consult label for appropriate protective clothing.<br>Apply at a spray volume of 850 to 1,000 L/ha (340 to 400 L/ac) water. |

Herbicides provide temporary control of nuisance aquatic vegetation. Alternate methods such as mechanical removal (submergents), dredging or substrate alteration (drainage ditches) can provide longer-term control. Management techniques for vegetation control in ponds include minimizing nutrient input, dredging excess sediment, logs and other organic debris, decreasing the surface-to-depth ratio and increasing the rate of pond turnover (flushing). Some aquatic plant and algae life should be accepted and tolerated as a vital component of a healthy ecosystem.

The use of herbicides may be complicated by the use of water by livestock or humans or by the presence of fish. If the water is flowing, the effect of the chemical on plant, animal or fish life downstream must be considered. Flowing water, by diluting the herbicide, makes control less effective.

Emergent species such as cattails and bulrushes may have to be sprayed for 2 or 3 consecutive years to bring them under complete control. The chemicals for cattails and other emergents are sprayed so as to thoroughly wet all exposed foliage. Paraquat and amitrole are most effective when cattails are coming into head. Consult the manufacturer's directions.

The vegetation also varies widely; some species are completely submerged, such as *Elodea* (*Elodea canadensis:* Canada waterweed) and algae; others are free floating, such as water lilies and emergent plants. Many emergents will grow equally as well on the moist shoreline as when their lower stems and roots are in water. Where these emergent species have taken possession of the shoreline, control measures must embrace that area as well as the water.

*Chara* (Chara stonewort, muskgrass) is a grey-green to green plant-like algae, attached to the sediment or free floating, that has a very strong musk odour in dense communities. It is brittle to the touch and will dry to a white powder upon removal from the water. This plant is difficult to control with moderate doses of algaecides, and dense communities should be removed mechanically. Tapegrass

# WATER WEEDS (AQUATIC PLANTS)

(wild celery) (*Vallisneria americana*), found in many recreational lakes, is resistant to all the currently recommended herbicides. It has long rubbery leaves and numerous short roots. Control is possible only by mechanical methods such as pulling.

Diquat (REWARD) provides good control of a wide variety of submergent species including water-milfoil, pondweeds, *Elodea canadensis* (Canada waterweed) and coontail. This herbicide is not effective against *Chara spp*. (muskgrass) and *Nitella sp*. Diquat should be applied on cloudy days in late afternoon, and care should be taken not to stir up the bottom, since turbidity reduces the effectiveness of treatment. Since diquat takes effect rapidly, decomposition of a large plant mass may deplete oxygen levels, which can cause fish to suffocate. Thus, in ponds where fish are present and growth is well established, no more than one-half to one-quarter of the pond should be treated at one time. Wait 2 weeks before treating again. The best time to apply these chemicals is late spring while the plants are growing rapidly. Since this is a contact chemical, control is achieved for one season, and repeat treatments must be made annually.

# 8. Appendices

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| 2,4-D | 2,4-D | h | Sn | 470 g/L | 2 | asparagus | **** |
| AATREX | atrazine | h | Su | 480 g/L | 2 | sweet corn | SYN |
| AATREX NINE-O | atrazine | h | WG | 90 | 2 | sweet corn | SYN |
| ACCENT | nicosulfuron | h | DF | 75 | 2 | certain varieties of sweet corn | DUQ |
| *acephate* | *See ORTHENE* | | | | | | |
| ACROBAT MZ | dimethomorph/ mancozeb | f | EC | 9/ 60 | 2 | potatoes | ENG |
| ADMIRE | imidacloprid | i | Fl | 240 g/L | 5 | potatoes, tomatoes, lettuce | BBB |
| AFESIN | monolinuron | h | EC | 200 g/L | 3 | potatoes, beans (kidney, lima, snap) | AET |
| AFOLAN F | linuron | h | Su | 480 g/L | 3 | asparagus, carrots, celery, dill, parsnips, potatoes, sweet corn | AET |
| AGRICULTURAL WEED KILLER #1 | mineral oil (herbicidal) | h | Li | 100 | 6 | carrots, celery, dill, parsley, parsnips | VAR |
| AGROX B-3 | diazinon/lindane/ captan | s | D | 15/16.6/ 33.5 | 2 | beans, peas, sweet corn | NOR |
| AGROX D-L Plus | diazinon/lindane/ captan | s | D | 11/25/ 15 | 2 | beans, peas, sweet corn | NOR |
| ALANAP-3 | naptalam | h | Sn | 240 g/L | 3 | cucumbers, melons, squash, pumpkins | UNR |
| ALIETTE 80 WDG | fosetyl-al | f | WG | 80 | 5 | lettuce, onions, broccoli, bok choy | AET |
| AMITROL-T | amitrole | h | Sn | 200 g/L | 3 | peas | NUA |
| APM 50 W INSTAPAK | azinphos methyl | i | WP | 50 | 5 | cabbages, cauliflower, broccoli, Brussels sprouts, tomatoes | NOR |
| APRON XL LS | metalaxyl-m | s | Li | 33.3 | 2 | beans, table beets, carrots, onions, peas, spinach, sweet corn, sugarbeets | SYN |
| ASSURE II | quizalofop-p-ethyl | h | EC | 96 g/L | 2 | sugarbeets | DUQ |
| *atrazine* | *See AATREX, AATREX NINE-O, ATRAZINE* | | | | | | |
| ATRAZINE 480 | atrazine | h | Su | 480 g/L | 2 | sweet corn | UAG |
| ATRAZINE 80W | atrazine | h | WP | 80 | 2 | sweet corn | **** |
| ATRAZINE 90W | atrazine | h | WG | 90 | 2 | sweet corn | **** |
| ATRAZINE 500 | atrazine | h | Su | 500 g/L | 2 | sweet corn | CPM |
| AVADEX BW | triallate | h | EC | 400 g/L | 3 | sugarbeets | MOL |
| *azinphos-methyl* | *See APM, GUTHION, SNIPER* | | | | | | |
| *Bacillus thuringiensis* | *See DIPEL, NOVODOR, THURICIDE* | | | | | | |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide

n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate

EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate

SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| **Examples of Brand Name/ Trade Name**[1] | **Active Ingredient/ Common Name** | **Use** | **Formulation** | **Guaranteed % Active Unless Stated** | **Ontario Schedule**[2] | **Crop Recommended Registrations** | **Company of Agent's Code** |
|---|---|---|---|---|---|---|---|
| BASAGRAN | bentazon | h | Sn | 480 g/L | 3 | peas, lima & snap beans, sweet corn | BAZ |
| BASAMID | dazomet | h | Gr | 98 | 2 | eggplant, lettuce, peppers, tomato seedbeds | BAZ |
| BENLATE 50 WP | benomyl | f | WP | 50 | 3 | beans, carrots, cucumbers, tomatoes | DUQ |
| *benomyl* | *See BENLATE* | | | | | | |
| *bensulide* | *See PREFAR* | | | | | | |
| *bentazon* | *See BASAGRAN* | | | | | | |
| *bentazon/atrazine* | *See LADDOCK* | | | | | | |
| BETAMIX | desmedipham/ phenmedipham | h | EC | (1:1)/ 150 g/L | 2 | sugarbeets | AET |
| BETANEX | desmedipham | h | EC | 150 g/L | 3 | sugarbeets | AET |
| BIOPROTEC CAF | Bacillus thuringiensis | i | Su | 11,400 IU/mg | 3 | broccoli, Brussels sprouts, cabbages, cauliflower, kale, tomatoes | AEF |
| BLADEX 90 DF | cyanazine | h | DF | 90 | 2 | sweet corn | DUQ |
| BLADEX LIQUID | cyanazine | h | Li | 480 g/L | 2 | sweet corn | DUQ |
| BONANZA 400 | trifuralin | h | EC | 400 g/L | 3 | snap & lima beans, Brussels sprouts,, cabbages, cauliflower, carrots, peas, peppers, transplant tomatoes, turnip | UAG |
| BOTRAN 75 W | dichloran | f | WP | 75 | 3 | garlic, lettuce, beans | GOW |
| BRAVO | chlorothalonil | f | Fl | 500 g/L | 3 | cabbages, cauliflower, broccoli, Brussels sprouts, carrots, celery, cucumbers, melons, pumpkins, squash, onions, parsnips, potatoes, sweet corn, tomatoes | SYN |
| *bromoxynil* | *See PARDNER* | | | | | | |
| BUSAN | metam sodium | h, f | Sn | 33 | 3 | vegetables (non-crop area) | BUL |
| *captan* | *See CAPTAN, MAESTRO* | | | | | | |
| CAPTAN FL | captan | s | Fl | 30 | 3 | beans, peas, sweet corn | NOR |
| CAPTAN WP | captan | f | WP | 50 or 80 | 3 | cucumbers, tomatoes | UAG |
| *carbaryl* | *See SEVIN XLR* | | | | | | |
| *carbathiin-thiram* | *See PRO-GRO* | | | | | | |
| *carbathiin-thiram-lindane* | *See VITAVAX RS* | | | | | | |
| *carbofuran* | *See FURADAN* | | | | | | |
| *chlorothalonil* | *See BRAVO* | | | | | | |
| *chlorpyrifos* | *See LORSBAN, PYRIFOS, PYRINEX* | | | | | | |
| CIPC | chlorpropham | h | GR | 20 | 2 | carrots, lettuce, onions, spinach | STD |
| CIPC EC | chlorpropham | h | EC | 480 g/L | 2 | potatoes | |
| *clethodim* | *See SELECT* | | | | | | |
| *clopyralid* | *See LONTREL* | | | | | | |
| COPPER 53 W | copper sulfate | f | WP | 53 | 2 | beets, cabbages, cauliflower, broccoli, Brussels sprouts, celery, cucumbers, squash, pumpkins, melons, potatoes, peppers | UAG |
| *copper hydroxide* | *See PARASOL, KOCIDE 101, DF* | | | | | | |
| *copper oxychloride* | *See COPPER SPRAY* | | | | | | |
| *copper sulphate* | *See COPPER 53 W* | | | | | | |
| *copper ethanolamine* | *See CUTRINE PLUS* | | | | | | |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| COPPER SPRAY | copper oxychloride | f | WP | 50 | 3 | celery, potatoes, cucumbers, melons, pumpkins, squash | UAG |
| COUNTER 15G | terbufos | i | Gr | 15 | 5 | rutabagas, sugarbeets | BAZ |
| CURZATE | cymoxanil | f | DF | 60 | 2 | potatoes | DUQ |
| CUTRINE PLUS | copper ethanolamine | h | Sn | 9 | 2 | for use in ponds | APB |
| *cyanazine* | *See BLADEX* | | | | | | |
| *cycloate* | *See RO-NEET* | | | | | | |
| *cyhalothrin-lambda* | *See MATADOR* | | | | | | |
| *cymoxanil* | *See CURZATE* | | | | | | |
| *cypermethrin* | *See CYMBUSH, RIPCORD* | | | | | | |
| *cyromazine* | *See GOVERNOR* | | | | | | |
| CYGON | dimethoate | i | EC | 480 g/L | 2 | asparagus, beans, beets, cabbages, cauliflower, broccoli, Brussels sprouts, kale, eggplant, lettuce, peas, peppers, potatoes, rutabagas, Chinese broccoli, Chinese cabbage, pak choy, spinach, tomatoes | BAT,<br>CAU |
| CYMBUSH | cypermethrin | i | EC | 250 g/L | 2 | asparagus, broccoli, cabbages, cauliflower, Brussels sprouts, kale, carrots, celery, lettuce, onions, potatoes, rutabagas, sweet corn, tomatoes | SYN |
| *dazomet* | *See BASAMID* | | | | | | |
| DCT | diazinon/captan/ thiophanate-methyl | s | D | 6/18/ 14 | 3 | sweet corn | NOR |
| DECIS | deltamethrin | i | EC | 50 g/L | 2 | asparagus, broccoli, Brussels sprouts, cabbages, cauliflower, kale, onions, peppers, potatoes, sweet corn | AET |
| *deltamethrin* | *See DECIS* | | | | | | |
| DES-I-CATE | endothall | v | Li | 62 g/L | 2 | potatoes | CRX |
| *desmedipham* | *See BETANEX* | | | | | | |
| *desmedipham/phenmedipham* | *See BETAMIX* | | | | | | |
| DEVRINOL 50W | napropamide | h | WP | 50 | 3 | asparagus, broccoli, basil, cabbages, cauliflower, Chinese broccoli, Chinese cabbage, Asian radishes, kohlrabi, garlic, peppers, pumpkins, squash, rutabagas, tomatoes | UAG |
| DEVRINOL DF | | h | DF | | 3 | | |
| DIAZINON 50 W | diazinon<br>See DZN also | i | WP | 50 | 2 | beets, carrots, onions, parsnips, peppers, radishes, spinach, tomatoes | UAG |
| DIAZINON 500 EC | diazinon | i | EC | 500 g/L | 2 | table beets, lettuce, onions, parsnips, radishes, spinach, tomatoes | UAG |
| DIBROM | naled | i | EC | 864 g/L | 2 | broccoli, Brussels sprouts, cabbages, cauliflower, kale, mustard greens, lima bean, celery, lettuce, endive, onions, peas, potatoes, spinach, sugarbeets, tomatoes | UAG |
| *dichloran* | *See BOTRAN* | | | | | | |
| *dichlorpropene/chloropicrin* | *See TELONE C17R* | | | | | | |
| *diclofop-methyl* | *See HOE-GRASS-284* | | | | | | |
| *dicofol* | *See KELTHANE* | | | | | | |
| *dimethenamid* | *See FRONTIER* | | | | | | |
| *dimethoate* | *See CYGON, LAGON* | | | | | | |
| *dimethomorph/mancozeb* | *See ACROBAT* | | | | | | |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
FI = flowable
GI = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| DIPEL 2X DF | Bacillus thuringiensis | i | DF | 32,000/mg | 3 | broccoli, Brussels sprouts, cabbages, cauliflower, kale, lettuce, parsley, rutabagas, spinach, Chinese broccoli, Chinese cabbage, Asian radishes, bok choy, mustard greens, sweet corn, tomatoes | VAN |
| *diquat* | *See REGLONE* | | | | | | |
| *disulfoton* | *See DI-SYSTON* | | | | | | |
| DI-SYSTON | disulfoton | i | Gr | 15 | 2 | potatoes | BBB |
| DITHANE F-45 | mancozeb | f | | 37 | 3 | potatoes | DWE |
| DITHANE M45, DG | mancozeb | f | DG | 80, 75 | 3 | carrots, celery, cucumbers, melons, squash, pumpkins, dry onions, potatoes, tomatoes, sugarbeets (not DG) | DWE |
| *diuron* | *See KARMEX* | | | | | | |
| D-L-C | diazinon-lindane-captan | s | D | 15/25/ 15 | 2 | beans, peas, sweet corn | UAG |
| DUAL MAGNUM | s-metolachlor | h | EC | 915 g/L | 2 | potatoes, transplanted tomatoes, rutabagas, transplanted cabbages, cauliflower, broccoli, yellow and green snap bean, lima bean, processing peas, sugarbeets | SYN |
| DUAL II MAGNUM | s-metolachlor/ benoxacor | h | EC | 915 g/L | 2 | sweet corn | SYN |
| DZN 600 EW | diazinon | i | EW | 600 g/L | 3 | beets, carrots, lettuce, onions, parsley, parsnips, peppers, radishes, spinach, swiss chard, tomatoes | ENG |
| EDGE | ethalfluralin | h | DC | 60 | 3 | transplanted peppers | DWE |
| ENDOSULFAN 50 W | endosulfan | i | WP | 50 | 2 | celery, cucumbers, melons, pumpkins, squash, head lettuce, spinach, tomatoes | UAG |
| *endothall* | *See HERBICIDE 273, DES-I-CATE* | | | | | | |
| EPTAM | EPTC | h | EC | 800 g/L | 3 | snap bean, potatoes | SYN |
| ERADICANE | EPTC/R25788 | h | EC | 800 g/L | 2 | sweet corn | SYN |
| ESTASOL | 2,4-D | h | EC | 564 g/L | 2 | asparagus, non-crop land | AET |
| ESTEMINE 2,4-D | 2,4-D | h | Sn | 470 g/L | 3 | asparagus, non-crop land | UAG |
| *ethalfluralin* | *See EDGE* | | | | | | |
| *ethofumesate* | *See NORTRON SC* | | | | | | |
| EXCEL SUPER | fenoxaprop-p-ethyl | h | EC | 80.5 g/L | 2 | asparagus, broccoli, cabbages, cauliflower, carrots, dry onions, peas, potatoes, tomatoes | AET |
| *fenoxaprop-p-ethyl* | *See EXCEL SUPER* | | | | | | |
| FERBAM | ferbam | f | WG | 76 | 3 | transplant lettuce | UAG |
| *fluazifop-p-ethyl* | *See FUSILADE II* | | | | | | |
| *fomesafen* | *See REFLEX* | | | | | | |
| *fosetyl-al* | *See ALIETTE* | | | | | | |
| FRONTIER | dimethenamid | h | EC | 900 g/L | 3 | sweet corn | BAZ |
| FURADAN | carbofuran | i | FI | 480 g/L | 5 | peppers, sweet corn, potatoes | BBB |
| FUSILADE II | fluazifop-p-butyl | h | EC | 125 g/L | 5 | broccoli, Brussels sprouts, cabbages, cauliflower, cucumbers, onions, potatoes, rutabagas, tomatoes | SYN |
| GAVEL 75 DF | zoxamide/mancozeb | f | DF | 75 | 3 | potatoes | DWE |
| GESAGARD 480 | prometryne | h | Su | 480 g/L | 2 | carrots, celery, leeks, peas | SYN |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide

n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate

EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate

SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company or Agent's Code |
|---|---|---|---|---|---|---|---|
| *glufosinate ammonium* | *See IGNITE* | | | | | | |
| GLYFOS | glyphosate | h | Su | 360 g/L | 6 | same as Renegade, etc. | CAU |
| *glyphosate* | *See GLYFOS, LAREDO, RENEGADE, ROUNDUP, TOUCHDOWN, WRANGLER* | | | | | | |
| *glyphosate/glufosinate ammonium* | *See ROUNDUP FASTFORWARD PRESEED* | | | | | | |
| GOAL 2XL | oxyfluorfen | h | EC | 240 g/L | 1 | onions | DWE |
| GOVERNOR | cyromazine | s | WP | 75 | 5 | onion seed treatment | SYN |
| GRAMOXONE | paraquat | h | Sn | 200 g/L | 2 | stale seedbed, inter-row weeding | SYN |
| GUTHION SP | azinphos methyl | i | WP | 50 | 5 | broccoli, Brussels sprouts, cabbages, cauliflower, tomatoes, melons, pumpkins, Chinese cabbage | BBB |
| GUTHION 240 SC | azinphos methyl | i | SC | 240 g/L | 5 | cucumbers, potatoes, Chinese cabbage, tomatoes | BBB |
| HERBICIDE 273 | endothall | h | Sn | 360 g/L | 2 | sugarbeets | EFA |
| HOE-GRASS-284 | diclofop-methyl | h | EC | 284 g/L | 3 | snap & lima bean, carrots, onions, peas, potatoes | AET |
| IGNITE | glufosinate ammonium | h, v | Sn | 150 g/L | 3 | potatoes, asparagus, carrots, lettuce, onions | AET |
| *imidacloprid* | *See ADMIRE* | | | | | | |
| *imazethapyr* | *See PURSUIT* | | | | | | |
| IMIDAN | phosmet | i | WP | 50 | 3 | carrots, celery | GOW |
| *iprodione* | *See ROVRAL* | | | | | | |
| KARMEX | diuron | h | DF | 80 | 2 | asparagus | GRN |
| KELTHANE | dicofol | m | WP | 50 | 2 | beans, cucumbers, melons, pumpkins, squash | DWE |
| KERB | propyzamide | h | WP | 50 | 3 | lettuce | DWE |
| KOCIDE 101 | copper hydroxide | f | WP | 77 | 2 | cucumbers, peppers, tomatoes, potatoes, sugarbeets, vegetable transplants in greenhouse (tomatoes, peppers) | GRN |
| KOCIDE DF | copper hydroxide | f | DF | 61.4 | 2 | peppers, potatoes | GRN |
| LADDOK | bentazon/atrazine | h | Su | (1:1)/400 | 2 | sweet corn | BAZ |
| LAGON | dimethoate | i | EC | 480 g/L | 2 | asparagus, beans, cabbages, cauliflower, broccoli, Brussels sprouts, kale, lettuce, peas, peppers, potatoes, spinach, tomatoes, eggplant, Chinese broccoli, Chinese cabbage, pak choy | UAG |
| LANNATE T-N-G | methomyl | i | SP | 90 | 2 | beans, broccoli, Brussels sprouts, cabbages, cauliflower, head lettuce, peas, sweet corn, tomatoes | DUQ |
| LAREDO | glyphosate | h | Sn | 356 g/L | 3 | preplant/post-harvest all crops | MOL |
| LENTAGRAN | pyridate | h | WP | 45 | 3 | cabbages, sweet corn, tomatoes | SYN |
| LEXONE DF | metribuzin | h | DF | 75 | 2 | asparagus, potatoes, transplant tomatoes | DUQ |
| LINURON 480 | linuron<br>See AFOLAN, LOROX also | h | Su | 480 g/L | 3 | asparagus, carrots, celery, dill, parsnips, potatoes, sweet corn | UAG |
| LONTREL 360 | clopyralid | h | Sn | 360 g/L | 2 | broccoli, cabbages, cauliflower, nappa cabbage, Asian radishes, Chinese broccoli, mustard cabbage, rutabagas | DWE |
| LOROX DF | linuron | h | DF | 50 | 3 | asparagus, carrots, celery, dill, parsnips, potatoes, sweet corn | GRN |
| LOROX L | linuron | h | Su | 480 g/L | 3 | asparagus, carrots, celery, dill, parsnips, potatoes, sweet corn | GRN |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| **Examples of Brand Name/ Trade Name**[1] | **Active Ingredient/ Common Name** | **Use** | **Formulation** | **Guaranteed % Active Unless Stated** | **Ontario Schedule**[2] | **Crop Recommended Registrations** | **Company of Agent's Code** |
|---|---|---|---|---|---|---|---|
| LORSBAN 15G | chlorpyrifos | i | Gr | 15 | 2 | onions, broccoli, Brussels sprouts, cabbages, cauliflower, rutabagas | DWE |
| LORSBAN 4E | chlorpyrifos | i | EC | 480 g/L | 2 | broccoli, Brussels sprouts, bulb onions, cabbages, carrots, cauliflower, celery, Chinese cabbage, Chinese broccoli, cucumbers, garlic, pak choy, radishes, Asian radishes, peppers, potatoes, rutabagas, sugarbeets, sweet corn | DWE |
| LORSBAN 50W | chlorpyrifos | i | WP | 50 | 2 | cabbages | DWE |
| MAESTRO | captan | f | DF | 75 | 2 | cucumbers, tomatoes, vegetable transplants in greenhouse (crucifer, eggplant, peppers, tomatoes, celery) | TMO |
| MALATHION 25W | malathion | i | WP | 25 | 3 | asparagus, beans, beets, cucumbers, melons, pumpkins, squash, peas, spinach, tomatoes | **** |
| MALATHION 500 E | malathion | i | EC | 500 g/L | 3 | asparagus, beans, beets, celery, cucumbers, garlic, melons, pumpkins, radishes, squash, peas, tomatoes, lettuce, peppers, sugarbeets | **** |
| *maleic hydrazide* | *See ROYAL MH 60* | | | | | | |
| *mancozeb* | *See DITHANE, TUBERSEAL, POTATO ST, PENNCOZEB, MANZATE* | | | | | | |
| MANZATE 200 DF | mancozeb | f | DF | 75 | 3 | carrots, celery, onions, cucumbers, potatoes, tomatoes, sugarbeets | GRN |
| MATADOR | cyhalothrin-lambda | i | EC | 120 g/L | 2 | broccoli, Brussels sprouts, cabbages, cauliflower, garlic, head lettuce, onions, potatoes, sweet corn, tomatoes | SYN |
| MAXIM 480 | fludioxonil | s | Fl | 40.3 | 2 | sweet corn | SYN |
| MAXIM PSP | fludioxonil | s | DP | 0.5 | 2 | potato seed piece | SYN |
| *MCPB/MCPA* | *See TROPOTOX PLUS* | | | | | | |
| *metalaxyl* | *See RIDOMIL GOLD, APRON* | | | | | | |
| *metalaxyl/ chlorothalonil* | *See RIDOMIL/BRAVO* | | | | | | |
| *metam sodium* | *See BUSAN, VAPAM* | | | | | | |
| *methamidophos* | *See MONITOR* | | | | | | |
| *methomyl* | *See LANNATE* | | | | | | |
| METHOXYCHLOR | methoxychlor | i | WP | 50 | 3 | asparagus, cucumbers, squash, pumpkins | UAG |
| *methyl bromide/ chloropicrin* | *See TERR-O-GAS 67* | | | | | | |
| *metiram* | *See POLYRAM* | | | | | | |
| *metobromuron* | *See PATORAN FL* | | | | | | |
| *metribuzin* | *See SENCOR, LEXONE* | | | | | | |
| MICROSCOPIC SULPHUR | sulphur | f | WP | 92 | 6 | rutabagas | UAG |
| *mineral oil* | *See AGRICULTURAL WEED KILLER, SUPERIOR OIL 70* | | | | | | |
| MONITOR | methamidophos | i | EC | 480 g/L | 5 | broccoli, Brussels sprouts, cabbages, cauliflower, head lettuce, potatoes | TMO |
| *monolinuron* | *See AFESIN* | | | | | | |
| *myclobutanil* | *See NOVA* | | | | | | |
| *naled* | *See DIBROM* | | | | | | |
| *napropamide* | *See DEVRINOL* | | | | | | |
| *naptalam* | *See ALANAP-3* | | | | | | |
| *nicosulfuron* | *See ACCENT* | | | | | | |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| NO-DAMP | oxine benzoate | f | Li | 2.5 | 3 | vegetable seedlings in greenhouse | PLG |
| NORTRON SC | ethofumesate | h | SC | 480 g/L | 2 | sugarbeets | AET |
| NOVA 40W | myclobutanil | f | WP | 40 | 2 | asparagus | DWE |
| NOVODOR | Bacillus thuringiensis | i | Fl | 15,000/g | 3 | potatoes, tomatoes | VAN |
| ORTHENE | acephate | i | Sp | 75 | 2 | broccoli, Brussels sprouts, cabbages, cauliflower, celery, head lettuce, peppers, potatoes, sweet corn, tomatoes | TMO |
| *oxamyl* | *See VYDATE* | | | | | | |
| *oxine benzoate* | *See NO-DAMP* | | | | | | |
| *oxyfluorfen* | *See GOAL 2XL* | | | | | | |
| *paraquat* | *See GRAMOXONE* | | | | | | |
| PARASOL | copper hydroxide | f | WP | 50 | 3 | beans, peppers, potatoes, sugarbeets, tomatoes | UAG |
| PARATHION | parathion | i | EC | 960 g/L | 5 | table beets, broccoli, Brussels sprouts, cabbages, carrots, cauliflower, celery, kale, lettuce, onions, peas, spinach | UAG |
| PARDNER | bromoxynil | h | EC | 280 g/L | 2 | garlic, sweet corn | AET |
| PATORAN FL | metobromuron | h | Su | 400 g/L | 2 | lima, snap, adzuki bean, potatoes | SYN |
| *pendimethalin* | *See PROWL* | | | | | | |
| PENNCOZEB | mancozeb | f | DF | 75 | 3 | carrots, celery, cucumbers, melons, pumpkins, squash, onions, potatoes, sugarbeets | CRX |
| *permethrin* | *See POUNCE* | | | | | | |
| *phenmedipham* | *See SPIN-AID* | | | | | | |
| *phorate* | *See THIMET* | | | | | | |
| *phosmet* | *See IMIDAN* | | | | | | |
| PIRIMOR 50 DF | pirimicarb | i | DF | 50 | 2 | asparagus, lettuce, peas, peppers, potatoes, spinach, sweet corn | SYN |
| POAST ULTRA | sethoxydim | h | EC | 450 g/L | 3 | snap & lima bean, peas, onions, tomatoes, potatoes, cucumbers, broccoli, cabbages, cauliflower, Chinese broccoli, Asian radishes, kohlrabi, nappa cabbage, mustard cabbage, garlic, sweet potatoes, peppermint, spearmint | BAZ |
| POLYRAM 16 DUST | metiram | s | D | 16 | 3 | potato seed piece | BAZ |
| POLYRAM 80 DF | metiram | f | DF | 80 | 3 | asparagus, carrots, celery, potatoes, tomatoes | BAZ |
| POTATO ST 16 | mancozeb | s | D | 16 | 3 | potato seed piece | UAG |
| POUNCE | permethrin | i | EC | 384 g/L | 3 | asparagus, beans, broccoli, Brussels sprouts, cabbages, cauliflower, Chinese broccoli, Chinese cabbage, pak choy, peppers, potatoes, radishes, rutabagas, sweet corn, tomatoes, table beets, carrots, lettuce, onions, peas | UAG |
| PREFAR | bensulide | h | EC | 480 g/L | 3 | cucumbers | UAG |
| PRIMEXTRA II MAGNUM | s-metolachlor/ benoxacor/atrazine | h | SC | (1:0.8)/ 720 g/L | 2 | sweet corn | SYN |
| PRINCEP NINE-T | simazine | h | WG | 90 | 2 | sweet corn, asparagus | SYN |
| PRISM | rimsulfuron | h | DF | 25 | 2 | potatoes, transplanted processing tomatoes | DUQ |
| PRO-GRO | carbathiin/thiram | s | D | 30/50 | 3 | onions | UNR |
| *prometryne* | *See GESAGARD* | | | | | | |
| *propamocarb/HCl/chlorothalonil* | *See TATTOO C* | | | | | | |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| *propiconazole* | *See TOPAS* | | | | | | |
| *propyzamide* | *See KERB* | | | | | | |
| PROWL 400 | pendimethalin | h | EC | 400 g/L | 5 | onions | BAZ |
| PURSUIT | imazethapyr | h | Sn | 240 g/L | 2 | processing peas, snap bean | BAZ |
| PYRAMIN FL | pyrazon | h | Su | 430 g/L | 3 | sugarbeets, table beets | BAZ |
| *pyrazon* | *See PYRAMIN* | | | | | | |
| *pyridate* | *See LENTAGRAN* | | | | | | |
| PYRIFOS 15 G | chlorpyrifos | i | Gr | 15 | 3 | same as Lorsban 15G | UAG |
| PYRIFOS | chlorpyrifos | i | WP | 50 | 2 | same as Lorsban 50 W | UAG |
| PYRINEX 480 EC | chlorpyrifos | i | EC | 480 g/L | 2 | same as Lorsban 4E | UAG |
| QUINTOZENE | quintozene (PCNB) | f | WP | 75 | 3 | broccoli, Brussels sprouts, cabbages, cauliflower | PLG |
| *quizalofop-p-ethyl* | *See ASSURE II* | | | | | | |
| REFLEX | fomesafen | h | Sn | 240 g/L | 2 | beans (white, kidney, snap) | SYN |
| REGLONE | diquat | h | Li | 200 g/L | 2 | potato vine killing, adzuki bean, stale seedbed and inter-row weeding | SYN |
| REGLONE A | diquat (aquatic) | h | Li | 200 g/L | 2 | aquatic weed control | SYN |
| RENEGADE | glyphosate | h | Sn | 356 g/L | 3 | preplant or post-harvest with no cropping restrictions | MOL |
| RIDOMIL GOLD | metalaxyl-M | f | EC | 480 g/L | 2 | snap bean | SYN |
| RIDOMIL/BRAVO | metalaxyl/ chlorothalonil | f | EC | 240/ 500 g/L | 2 | potatoes | SYN |
| RIDOMIL 2G | metalaxyl | f | Gr | 2 | 2 | carrots, lettuce | SYN |
| RIDOMIL MZ GOLD | metalaxyl-M + mancozeb | f | WP | 68 | 2 | lettuce, onions, potatoes | SYN |
| *rimsulfuron* | *See PRISM* | | | | | | |
| RIPCORD | cypermethrin | i | EC | 400 g/L | 2 | broccoli, Brussels sprouts, cabbages, cauliflower, kale, lettuce, potatoes, sweet corn, carrots, onions | BAZ |
| RIVAL | trifluralin | h | EC | 500 g/L | 3 | beans (snap, lima), peas, turnip, carrots, direct seeded cabbages & cauliflower, transplants of tomato, peppers, Brussels sprouts, broccoli, cabbages, cauliflower | AET |
| RO-NEET | cycloate | h | EC | 720 g/L | 3 | red beets, spinach, sugarbeets | SYN |
| RONILAN | vinclozolin | f | DF | 50 | 2 | beans, lettuce | BAZ |
| ROTENONE 5% WP | rotenone | i | WP | 5 | 3 | cucumbers, melons, pumpkins, squash, asparagus | WIL |
| ROTENONE DUST | rotenone | i | D | 1 | 4 | cucumbers, melons, pumpkins, squash | WIL |
| ROUNDUP | glyphosate | h | Sn | 356 g/L | 3 | same as Renegade | MOL |
| ROUNDUP DRY | glyphosate | h | SG | 64 | 3 | same as Renegade | MOL |
| ROUNDUP FASTFORWARD PRESEED | glyphosate/ glufosinate ammonium | h | Sn | (30:1)/ 310 g/L | 3 | same as Renegade | MOL |
| ROVRAL | iprodione | f | WP | 50 | 3 | beans, cabbages, cauliflower, garlic, lettuce, carrots | AET |
| ROYAL MH 60 | maleic hydrazide | pgr | SG | 60 | 3 | dry onions, potatoes | GUS |
| SELECT | clethodim | h | EC | 240 g/L | 2 | onions, potatoes | AET |
| SENATOR 70 WP | thiophanate-methyl | f | WP | 70 | 3 | sugarbeets | ENG |
| SENATOR PSPT | thiophanate-methyl | s | D | 10 | 6 | potato seed piece | ENG |

## Appendix A.
## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
I – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| SENCOR 500 F | metribuzin | h | Su | 500 g/L | 2 | asparagus, potatoes, transplant tomatoes | BBB |
| SENCOR 75 DF | metribuzin | h | DF | 75 | 2 | asparagus, potatoes, transplant tomatoes | BBB |
| SENCOR SOLUPAK | metribuzin | h | WG | 75 | 2 | asparagus, potatoes, transplant tomatoes | BBB |
| *sethoxydim* | *See POAST ULTRA* | | | | | | |
| SEVIN XLR PLUS | carbaryl | i | Su | 480 g/L | 3 | asparagus, beans, broccoli, Brussels sprouts, cabbages, cauliflower, kale, kohlrabi, carrots, celery, cucumbers, melons, pumpkins, squash, eggplant, lettuce, endive, parsley, peppers, radishes, rutabagas, sweet corn, tomatoes, Chinese cabbage, mustard greens | AET |
| SIMADEX | simazine<br>See PRINCEP NINE-T also | h | Su | 500g/L | 2 | asparagus, sweet corn | AET |
| SIMAZINE 480 | simazine | h | Su | 480 g/L | 2 | asparagus, sweet corn | UAG |
| SIMAZINE 80 W | simazine | h | WP | 80 | 2 | asparagus, sweet corn | UAG |
| SINBAR | terbacil | h | WP | 80 | 2 | asparagus, peppermint, spearmint | DUQ |
| *s-metolachlor* | *See DUAL MAGNUM* | | | | | | |
| *s-metolachlor/benoxacor* | *See DUAL MAGNUM II* | | | | | | |
| *s-metolachlor/benoxacor/atrazine* | *See PRIMEXTRA II MAGNUM* | | | | | | |
| SNIPER 50 W | azinphos methyl | i | WP | 50 | 5 | same as Guthion | UAG |
| SNIPER 240 E | azinphos methyl | i | EC | 240 g/L | 5 | broccoli, Brussels sprouts, cabbages, cauliflower, cucumbers, potatoes, tomatoes | UAG |
| SPIN-AID | phenmedipham | h | EC | 150 g/L | 3 | table beets | AET |
| STREPTOMYCIN 17 | streptomycin sulphate | b, s | WP | 17 | 3 | broccoli, Brussels sprouts, cabbages, cauliflower, rutabagas | UAG |
| *sulphur* | *See MICRONIASUL, MICROSCOPIC SULPHUR* | | | | | | |
| SUPERIOR 70 OIL | mineral oil | a, i | Li | 99 | 6 | rutabagas | *** |
| SUPRA CAPTAN 80 WDG | captan | f | WG | 80 | 2 | tomatoes, vegetable transplants in greenhouse (cole crops, eggplant, peppers, tomatoes, celery) | UAG |
| TATTOO C | propamocarb HCl/ chlorothalonil | f | EC | (1:1)/ 375 g/L | 2 | potatoes | AET |
| TELONE C17R | dichloropropene/ chlorothalonil | n, f | Li | 78/ 19.5 | 2 | non-crop areas | DWE |
| TELONE II | 1,3 dichloropropene | n | Li | 94 | 2 | as above | DWE |
| *terbacil* | *See SINBAR* | | | | | | |
| *terbufos* | *See COUNTER* | | | | | | |
| TERR-O-GAS 67 | methyl bromide/ chloropicrin | h | Li | 67/ 31 | 1 | greenhouse seedbeds | GRC |
| THIMET | phorate | i | Gr | 15 | 2 | potatoes | BAZ |
| THIODAN 50 WP | endosulfan | i | WP | 50 | 2 | celery, cucumbers, melon, pumpkin, squash, eggplant, peppers, potatoes, broccoli, Brussels sprouts, cabbages, cauliflower | AET |
| THIODAN 4 EC | endosulfan | i | EC | 400 g/L | 2 | beans, broccoli, Brussels sprouts, cabbages, cauliflower, celery, cucumbers, melons, pumpkins, squash, eggplant, head lettuce, peppers, potatoes, rutabagas, spinach, tomatoes, peas | AET |

## Appendix A.

## Pesticides Used on Vegetable Crops in Ontario (Continued)

**Use Codes**

a – acaricide
b – bactericide
f – fungicide
h – herbicide
i – insecticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

**Formulation Codes**

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

| Examples of Brand Name/ Trade Name[1] | Active Ingredient/ Common Name | Use | Formulation | Guaranteed % Active Unless Stated | Ontario Schedule[2] | Crop Recommended Registrations | Company of Agent's Code |
|---|---|---|---|---|---|---|---|
| THIONEX | endosulfan | i | EC | 400 g/L | 2 | same as Endosulfan | UAG |
| THIONEX 50 WP | endosulfan | i | WP | 50 | 2 | same as Endosulfan | UAG |
| *thiophanate-methyl* | *See SENATOR PSPT* | | | | | | |
| THIRAM | thiram | s | D | 75 | 2 | beans, table beets, broccoli, Brussels sprouts, cabbages, cauliflower, lettuce, onions, peas, rutabagas, spinach, sweet corn, sugarbeets | GUS |
| THURICIDE | Bacillus thuringiensis | i | Li | 4,000/mg | 3 | broccoli, Brussels sprouts, cabbages, cauliflower, kale, lettuce, celery, mustard greens, spinach, tomatoes | NOR |
| TILT 250 E | propiconazole | f | EC | 250 g/L | 2 | sweet corn | SYN |
| TOPAS | propiconazole | f | EC | 250 g/L | 2 | rutabagas, asparagus | ENG |
| TOUCHDOWN 480 | glyphosate TMS | h | Sn | 330 g/L | 6 | same as Roundup & Renegade | SYN |
| TREFLAN | trifluralin | h | EC | 545 g/L | 3 | same as Rival and Bonanza | DWE |
| TREFLAN EC | trifluralin | h | EC | 480 g/L | 3 | same as Rival and Bonanza | |
| *triallate* | *See AVADEX BW* | | | | | | |
| *trifluralin* | *See BONANZA, RIVAL, TREFLAN* | | | | | | |
| *triflusulfuron-methyl* | *See UPBEET* | | | | | | |
| TROPOTOX PLUS | MCPB/MCPA | h | Sn | 400 g/L | 3 | peas | AET |
| TUBERSEAL | mancozeb | s | D | 16 | 3 | potato seed piece | NOR |
| UPBEET | triflusulfuron-methyl | h | DF | 50 | 2 | sugarbeets | DUQ |
| VAPAM | metam sodium | h, f | Sn | 380 g/L | 3 | preplant site preparation | UAG |
| *vinclozolin* | *See RONILAN* | | | | | | |
| VITAVAX RS | carbathiin/thiram/ lindane | s | Fl | 45 g/L/90 g/L/ 680 g/L | 2 | broccoli, Brussels sprouts, cabbages, cauliflower, rutabagas | GUS |
| VYDATE | oxamyl | i | Li | 240 g/L | 5 | potatoes | DUQ |
| WRANGLER | glyphosate | h | Sn | 356 g/L | 3 | same as Renegade, Laredo, etc. | MOL |
| ZINEB 80 W | zineb | f | WP | 80 | 3 | asparagus, broccoli, Brussels sprouts, cabbages, cauliflower, carrots, celery, lettuce, onions | UAG |

[1] Mention of a brand or trade name in this table does not constitute a guarantee or warranty of the product by the Ontario Weed Committee or the Ontario Crop Protection Committee nor that these products are approved to the exclusion of comparable products. All trade names are capitalized.

[2] **Ontario Classification Schedule:**

Listed below are the schedules classified under the *Pesticides Act*. The majority of materials listed for vegetables are classified as Schedule 2 or 5. Consult your local pest control product supplier or, for more information, contact the Ministry of the Environment and Energy office nearest you.

Schedule 1: Restricted. Use permit only.
Schedule 2: Restricted to certified agriculturists, licensed exterminators, registered custom sprayer and permit holders.
Schedule 3: Agriculturists and consumer use.
Schedule 4: Domestic products only.
Schedule 5: Limited to application on agricultural land. Similar to Schedule 2.
Schedule 6: Similar to Schedule 4 but may be registered for agricultural/commercial use, container size 1 L or greater.

## Appendix B.
## Pest Control Product Companies

| Code | Company/Agent | Web Site | Contact Number |
|---|---|---|---|
| **** | Various manufacturers | | |
| ABT | Abbott Laboratories Ltd. | www.abbott.com/about/namerica.htm | 1-800-384-2474 |
| APB | Applied Biochemists Inc. | www.appliedbiochemists.com/ | 1-800-558-5106 |
| AET | Aventis | www.ca.cropscience.aventis.com | 1-888-283-6847 |
| BAZ | BASF Canada Inc. | www.basf.com/businesses/consumer/agproducts/ | 1-877-371-2273 |
| BAT | Bartlett, N. M. Inc. | | 1-800-263-1287 |
| BBB | Bayer Inc. | www.bayer.ca/ | 1-800-268-1331 |
| BUL | Buckman Laboratories of Canada Ltd. | | (450) 424-4404 |
| CRX | Cerexagri, Inc. | www.cerexagri.com/usa/ | (905) 827-9841 |
| CAU | Cheminova Canada | www.cheminova.com/ | 1-888-316-6260 |
| CPM | Cooper Mill Ltd | www.coopermill.com | (613) 473-4847 |
| DWE | Dow Agrosciences Canada Inc. | www.dowagro.ca | 1-800-667-3852 |
| DUQ | Dupont Canada Inc. | www.dupont.ca/ag/ | 1-800-667-3925 |
| EFA | Elf Atochem of Canada | www.elf-atochem.com/newelf/homepage.cfm | (905) 827-9841 |
| ENG | Engage Agro Inc. | www.engageagro.com | 1-800-900-5487 |
| GOW | Gowan | www.gowanco.com/ | 1-800-883-1844 |
| GRC | Great Lakes Chemical Corporation | www.greatlakescorp.com/ | (773) 478-3625 |
| GRN | Griffin Corporation | www.griffinllccanada.com/ | (229) 242-8635 |
| GUS | Gustafson | www.gustafson.ca/ | |
| MOL | Monsanto Canada Inc. | www.farmcentral.com | 1-800-667-4944 |
| NOR | Norac Concepts Inc. | www.noracconcepts.com | (613) 841-2907 |
| NUA | NuFarm Agriculture Inc. | www.nufarm.com/usa-top-frame.htm | 1-800-868-5444 |
| PLG | Plant Products Co. Ltd. | www.plantprod.com/ | 1-800-387-2449 |
| STD | StanChem Inc. | | (416) 259-8231 |
| SYN | Syngenta | www.syngenta.ca/ | 1-800-797-5040 |
| TMO | Tomen Agro | www.tomenagro.ca/ | (415) 536-3480 |
| UNR | Uniroyal Chemical | www.uniroyalchemical.com/ | 1-800-265-2157 |
| UAG | United Agri-Products | www.uap.ca | 1-800-265-4624 |
| VAN | Valent | www.valent.com/ | (905) 659-0886 |
| VAR | Van Waters & Rogers | www.vwr-ltd.com/ | 1-800-265-7671 |
| WBR | Wilbur Ellis Co. of Canada Ltd. | www.wilburellis.com/ | (306) 242-4553 |
| WIL | Wilson Laboratories | | (905) 639-7535 |

## Appendix C.
## Ontario Ministry of the Environment and Energy Pesticide Control Offices

| REGION<br>County | PESTICIDES OFFICER<br>Address | Telephone |
|---|---|---|
| **CENTRAL REGION**<br>Toronto, Halton, Peel, York, Durham | CHARLES ZUBOVITS<br>CATHY WRIGHT<br>5775 Yonge St, 8th Floor<br>Toronto, Ontario M2M 4J1 | Tel: (416) 326-3671<br>Tel: (416) 326-3477<br>Toll-Free: 1-800-810-8048<br>Fax: (416) 325-6347 |
| **WEST-CENTRAL REGION**<br>Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant | CHARLIE ROLAND<br>Ontario Government Building<br>119 King St. W., 12th Floor<br>Hamilton, Ontario L8P 4Y7 | Tel: (905) 521-7658<br>Toll-Free: 1-800-668-4557<br>Fax: (905) 521-7820 |
| **EASTERN REGION**<br>Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry , Haliburton, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Twsps of Airy, Murchison, Dickens, Lyell and Sabine) | ROBERTO SACILOTTO<br>LAUREL GRILLS<br>133 Dalton Ave.<br>P.O. Box 820<br>Kingston, Ontario K7L 4X6 | Tel: (613) 549-4000, ext. 2684<br>Tel: (613) 549-4000, ext. 2702<br>Fax: (613) 548-6908<br>Toll-Free: 1-800-267-0974 |
| **SOUTHWESTERN REGION**<br>Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth, Simcoe | GARY ROBERTS<br>695 Exeter Rd., 2nd Floor<br>London, Ontario N6E 1L3 | Tel: (519) 873-5047<br>Toll-Free: 1-800-265-7672<br>Fax: (519) 873-5020 |
| **NORTHERN REGION**<br>Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Muskoka | JOHN NEGUSANTI<br>199 Larch St., Ste. 1101<br>Sudbury, Ontario P3E 5P9 | Tel: (705) 564-3249<br>Toll-Free: 1-800-890-8516<br>Fax: (705) 564-4180 |
| Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West, Timmins | DON MITCHELL<br>435 James St. S., Ste. 331<br>Thunder Bay, Ontario P7E 6S7 | Tel: (807) 475-1712<br>Fax: (807) 475-1745 |
| **Standards Development Branch** | Pesticides Section<br>40 St. Clair Ave. W., 7th Floor<br>Toronto, Ontario M4V 1M2 | Tel: (416) 327-5519<br>Fax: (416) 327-2936 |
| **Approvals Branch** | Pesticides Licensing<br>2 St. Clair Ave. W., 12A Floor<br>Toronto, Ontario M4V 1L5 | Tel: (416) 314-8001<br>Toll-Free: 1-800-461-6290<br>Fax: (416) 314-8452 |

# Appendix D.
## Accredited Soil-Testing Laboratories in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.

***Note:*** There is no official accreditation in Ontario for tissue analysis, but all of the accredited soil-testing labs are monitored for proficiency on tissue analyses.

| Laboratory Name | Address | Telephone/Fax/E-mail | Contact |
|---|---|---|---|
| A & L Canada Laboratories East. Inc.<br>Web site: www.al-labs-can.com | 2136 Jetstream Rd.<br>London, Ontario N5V 3P5 | Tel: (519) 457-2575<br>Fax: (519) 457-2664<br>E-mail: aginfo@al-labs-can.com | Mr. Greg Patterson<br>Mr. Ian McLachlin |
| Accutest Laboratories<br>Web site: www.accutestlabs.com | 146 Colonnade Rd., Unit #8<br>Nepeasn, Ontario K2E 7Y1 | Tel: (613) 727-5692<br>Fax: (613) 727-5222<br>E-mail: phaulena@accutestlabs.com | Mrs. Lorna Wilson<br>Mr. Peter Haulena |
| Agri-Food Laboratories<br>Web site: www.agtest.com | 503 Imperial Rd., Unit #1<br>Guelph, Ontario N1H 6T9 | Tel: (519) 837-1600<br>Toll-Free: 1-800-265-7175<br>Fax: (519) 837-1242<br>E-mail: lab@agtest.com | Mr. Dale Cowan<br>Ms. Nora Wilson |
| Soil and Nutrient Laboratory[1] | University of Guelph<br>P.O. Box 3650<br>95 Stone Rd. W.<br>Guelph, Ontario N1H 2W1 | Tel: (519) 767-6226<br>Fax: (519) 767-6240<br>E-mail: info@lsd.uoguelph.ca | Ms. Virginia Kerslake |
| Stratford Agri Analysis<br>(A Daco Laboratories Ltd.) | 1131 Erie St., Box 760<br>Stratford, Ontario N5A 6W1 | Tel: (519) 273-4411<br>Toll-Free: 1-800-323-9089<br>Fax: (519) 273-4411<br>E-mail: info@stratfordagri.com | Mr. Dale Peters<br>Mr. Gary Roberts<br>Mr. Keith Lemp<br>Dr. Jim Brimner |

[1] Formerly Analytical Services, Land Resource Science.

## Appendix E.
## Crop Insurance

The Canada-Ontario Crop Insurance Program is publicly funded by the Government of Canada and the Province of Ontario and delivered by AGRICORP. The Federal and Provincial governments each contribute 25% of the premium cost and 50% of the administrative costs. Both these contributions enable an Ontario grower to purchase insurance coverage at a substantially reduced cost.

The grower's payment is considered an operating expense for income tax purposes. Crop insurance offers protection against a broad range of production hazards, including excessive rain, hail, excessive drought, freeze, frost, excessive wind and certain insects and diseases.

For further information, please call AGRICORP's Customer Action Centre at 1-888-AGRI-999 (1-888-247-4999).

AGRICORP
1 Stone Rd. W.
Box 3660, Station Central
Guelph, Ontario N1H 8M4
Tel: (519) 826-3276
Fax: (519) 826-4118
Web site: www.agricorp.com

### Ontario Crops Covered by a Crop Insurance Plan

| | | |
|---|---|---|
| **Fruit Crops** | | |
| apples (fruit and/or trees) | cherries, sweet and sour | grapes (fruit and/or vines) |
| peaches | pears | plums |
| strawberries | | |
| **Vegetable Crops** | | |
| asparagus | green beans and wax beans (processing) | beets (processing) |
| broccoli | cabbages | carrots (fresh) |
| carrots (processing) | cauliflower | celery |
| cucumbers (processing) | lettuce | lima beans (processing) |
| parsnips | peas (processing) | peppers |
| potatoes | rutabagas | seed onions |
| set onions | Spanish onions | butternut squash (processing) |
| sweet corn (fresh) | sweet corn (processing) | tomatoes (processing) |
| tomatoes (fresh) | | |
| **General Crops** | | |
| coloured beans | white beans | canola |
| corn (grain and silage) | seed corn | forage |
| new forage seeding | honey | peanuts |
| popping corn | soybeans | spring grain |
| sugarbeets | sunflower | red spring wheat |
| wheat, winter | industrial hemp | |
| **Tobacco** | | |
| black | flue-cured | |

## Appendix F.
## Other Contacts

**UNIVERSITY OF GUELPH**
Main Campus
Guelph, N1G 2W1
(519) 824-4120
www.uoguelph.ca

Alfred College
Alfred, K0B 1A0
(613) 679-2218
www.alfredc.uoguelph.ca/

Kemptville College
Kemptville, K0G 1J0
(613) 258-8336
www.kemptvillec.uoguelph.ca

Ridgetown College
Ridgetown, N0P 2C0
(519) 674-1500
www.ridgetownc.on.ca

**Department of Plant Agriculture**
www.plant.uoguelph.ca

Department of Plant Agriculture Kettleby
1125 Woodchopper's Lane, R.R. # 1
Kettleby, L0G 1J0
(905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Rd.
Simcoe, N3Y 4N5
(519) 426-7127

Department of Plant Agriculture, Vineland
Box 7000, 4890 Victoria Ave. N.
Vineland Station, L0R 2E0
(905) 562-4141

**Lab Services Division**
www.uoguelph.ca/labserv/

Pesticide and Trace Contaminants
P.O. Box 3650, 95 Stone Rd., W.
Guelph, N1H 8J7
(519) 767-6200

Pest Diagnostic Clinic
(519) 767-6256

**AGRICULTURE & AGRI-FOOD CANADA**
**Research Centres**
Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue, Ottawa, K1A 0C6
(613) 759-1952
http://res2agr.ca/ecorc/welcome.htm

Greenhouse and Processing Crops Research Centre
Harrow, N0R 1G0
(519) 738-2251
http://res2.agr.ca/harrow/

Southern Crop Protection and Food Research Centre
http://res2.agr.ca/london/pmrc/pmrchome.html

1391 Sandford St.
London, N5V 4T3
(519) 457-1470

Vineland Research Farm
4902 Victoria Ave. N.
Vineland, L0R 2E0
(905) 562-4113

Delhi Research Farm
Box 186 Schafer Rd.
Delhi, N4B 2W9
(519) 582-1950

**CANADIAN FOOD INSPECTION AGENCY**
www.cifa-acia.agr.ca

**Regional Offices (Plant Protection)**
Belleville
345 College St. E.
Belleville, K8N 5S7
(613) 969-3333

Hamilton
709 Main St. W., 101
Hamilton, L8S 1A2
(905) 572-4152

London
1200 Commissioners Rd. E., Unit 19
London, N5Z 4R3
(519) 691-1300

Niagara Falls
(Mailing address) R.R #1 P.O. Box #7
Niagara on the Lake, L0S 1J0
(Street address) 14154 Niagara River Parkway, Unit # 5
Niagara on the Lake
(905) 262-5331

Brantford
Federal Building, Dalhousie & Queen St, P.O. Box 637
Brantford, N3T 5P9
(519) 751-8157

Ottawa District
3 Observatory Crescent, Bldg. #3 Central
Experimental Farm, Ottawa, K1A 0C9
(613) 759-1571

Toronto Office
401 Champagne Dr., Unit 1
Downsview, M3J 2C6
(416) 954-1714

Windsor
441 University Ave. W., Suite 208
Windsor, N9A 5P9
(519) 252-7095

AGRICORP (Crop Insurance)
Customer Action Centre
1-888-AGRI-999 (1-888-247-4999)
P.O. Box 3660, Station Central
Guelph, Ontario N1H 8M4
www.agricorp.com

## Appendix G.
## Diagnostic Service

Samples for disease diagnosis, insect or weed identification, nematode counts and *Verticillium* testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Rd. W.
Guelph Ont.ario, N1H 8J7
Tel (519) 767-6256
Fax (519) 767-6240
E-mail pdc@lsd.uoguelph.ca

Payment must accompany samples at the time of submission. Submission forms are available at www.uoguelph.ca/pdc.

### Fee Schedule

| Procedures | Price/ Sample |
|---|---|
| **Plant Diseases** | |
| Diagnosis not requiring plating | $25.00 |
| Diagnosis requiring plating | $40.00 |
| Turf diagnosis | $50.00 |
| Bacterial identification using Biolog® | $95.00 |
| Detection of virus using Transmission Electron Microscopy | $85.00 |
| Detection of virus using ELISA (turnaround time = 5 working days; bulk rates are available) | $60.00 |
| **Weed Identification** | $40.00 |
| **Insects** | |
| Basic identification | $25.00 |
| Identification requiring dissection and/or extensive keys | $40.00 |
| **Nematode and Verticillium Counts** | **Price/ Sample** |
| Nematodes extracted from soil (Bearman Pan Method) | $25.00 |
| Soybean cyst nematode (SCN) + egg count | $35.00 |
| Nematodes extracted from roots | $60.00 |
| Verticillium count | $60.00 |

Turnaround time:
Nematodes extracted from soil takes 7 or 8 days.
Nematodes extracted from roots takes 15 days.
Cyst count takes 3 or 4 days.
Charges will be applied to each sample submitted.

**Payment:** Please make cheque payable to the University of Guelph. VISA and Mastercard are also accepted. Please do not mail cash.

## How to Sample for Nematodes

### Soil

#### *When to Sample*

Soil and root samples can be taken at any time of the year that the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May and June and again in September and October.

#### *How to Sample Soil*

Use a soil sampling tube, trowel or narrow-bladed shovel to take samples. Sample soil to a depth of 20–25 cm (8–10 in.). If the soil is bare, remove the top 2 cm (1 in.) prior to sampling. A sample should consist of 10 or more subsamples combined. Mix well. Then take a sample of $^1/_2$–1 L (1 pint–1 quart) from this. No one sample should represent more than 2.5 ha (6.25 ac). Mix subsamples in a clean pail or plastic bag.

#### *Sampling Pattern*

If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees, this is the drip line).

#### *Number of Subsamples*

Based on the total area sampled:

| | |
|---|---|
| 500 $m^2$ (5,400 $ft^2$) | 10 subsamples |
| 500 $m^2$–0.5 ha (5,400 $ft^2$–1.25 ac) | 25 subsamples |
| 0.5 ha–2.5 ha (1.25–6.25 ac) | 50 subsamples |

### Roots

From small plants, sample the entire root system plus adhering soil. For large plants, 10–20 g ($^1/_2$–1 oz.) dig fresh weight from the feeder root zone and submit.

### Problem Areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take samples from healthy areas in the same field. If possible, take both soil and root samples from problem and healthy areas in the same field.

### Sample Handling

#### *Soil Samples*

Place in plastic bags as soon as possible after collecting.

#### *Root Samples*

Place in plastic bags and cover with moist soil from the sample area.

#### *Storage*

Store samples at 5°C–10°C (40°C–50°F) and do not expose them to direct sunlight or extreme heat or cold (freezing). **Only living nematodes can be counted. Accurate counts depend on proper handling of samples.**

## Submitting Plant for Disease Diagnosis or Identification

### Sample Submission Forms

Forms can be obtained from your local Ontario Ministry of Agriculture and Food office. Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. For turfgrass, submit a 10–15 $cm^2$ piece of turf, including thatch and at least 5 cm of soil. Take the sample from the outside edge of a ring or patch, and include healthy and unhealthy turf, as well as the interface between. If symptoms are general, collect the sample from an area where they are of intermediate severity. **Completely dead material is usually inadequate for diagnosis.**

With plant specimens submitted for identification, include at least a 20–25-cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag to avoid drying out and contamination of the leaves by soil. Do **NOT** add moisture, as this encourages decay in transit. Cushion specimens and pack in a sturdy box to avoid damage during shipping. Avoid leaving specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

### Delivery

Deliver to the Pest Diagnostic Clinic as soon as possible by first class mail or by courier at the beginning of the week.

## Submitting Insect Specimens for Identification

### Collecting Samples

Place dead, hard-bodied insects and spiders in vials or boxes and cushion with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water, as this results in rot. Do not tape insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

## Appendix H.
## Ontario Ministry of Agriculture and Food Staff

| Specialty | Staff | Phone/Fax | E-mail |
|---|---|---|---|
| Brighton Resource Centre<br>95 Dundas St. E., RR #3<br>Brighton, ON K0K 1H0 | | General Tel: (613) 475-1630<br>Fax: (613) 475-3835 | |
| IPM Systems Specialist | Margaret Appleby | Tel: (613) 475-5850 | margaret.appleby@omafra.gov.on.ca |
| Delhi<br>Southern Crop Protection and Food Research Centre<br>Schafer Rd. Box 186<br>Delhi, ON N4B 2W9 | | General Tel: (519) 582-7220<br>Fax: (519) 582-4504 | |
| Tobacco Specialist | Dan Ramer | Tel: (519) 582-7220, ext. 264 | dan.ramer@omafra.gov.on.ca |
| Fergus Resource Centre<br>RR#1, County Road 18, Wellington Place<br>Fergus, ON N1M 2W3 | | General Tel: (519) 846-0941<br>Fax: (519) 846-8178 | |
| Agroforestry Specialist | Todd Leuty | Tel: (519) 846-3390 | todd.leuty@omafra.gov.on.ca |
| Harrow<br>Greenhouse and Processing Crops Research Centre<br>2585 County Road 20<br>Harrow, ON N0R 1G0 | | General Tel: (519) 738-2251<br>Fax: (519) 738-4564 | |
| Greenhouse Vegetable IPM Specialist | Gillian Ferguson | Tel: (519) 738-2251, ext. 406 | gillian.ferguson@omafra.gov.on.ca |
| Weed Management – Horticulture Program Lead | Leslie Huffman | Tel: (519) 738-2251, ext. 499 | leslie.huffman@omafra.gov.on.ca |
| Greenhouse Vegetable Specialist | Shalin Khosla | Tel: (519) 738-2251, ext. 405 | shalin.khosla@omafra.gov.on.ca |
| Kemptville Resource Centre<br>Box 2004, Concession Rd.<br>Kemptville, ON K0G 1J0 | | General Tel: (613) 258-8295<br>Fax: (613) 258-8392 | |
| Emerging Crops Specialist | Scott Banks | Tel: (613) 258-8359 | scott.banks@omafra.gov.on.ca |
| Agroforestry Specialist | Dave Chapeskie | Tel: (613) 258-8302 | dave.chapeskie@omafra.gov.on.ca |
| Field Crops, IPM Program Lead – Bilingual | Gilles Quesnel | Tel: (613) 258-8250 | gilles.quesnel@omafra.gov.on.ca |
| Lindsay Resource Centre<br>322 Kent St. W<br>Lindsay, ON K9V 2Z9 | | General Tel: (705) 324-6125<br>Fax: (705) 324-1638 | |
| Forage Specialist | Joel Bagg | Tel: (705) 324-5856 | joel.bagg@omafra.gov.on.ca |
| London Resource Centre<br>667 Exeter Road<br>London, ON N6E 1L3 | | General Tel: (519) 873-4070<br>Fax: (519) 873-4062 | |
| Horticulture Systems Specialist | John Gardner | Tel: (519) 873-4084 | john.gardner@omafra.gov.on.ca |
| New Liskeard<br>280 Armstrong St., Box 4070,<br>New Liskeard, ON P0J 1P0 | | General Tel: (800) 461-6132<br>Fax: (705) 647-7993 | |
| Agriculture and Rural Representative | Daniel Tasse | Tel: (705) 647-2085 | daniel.tasse@omafra.gov.on.ca |
| Ridgetown Resource Centre<br>Agronomy Building, Ridgetown College, Box 400, Main St. E.<br>Ridgetown, ON N0P 2C0 | | General Tel: (519) 674-1690<br>Fax: (519) 674-1564 | |
| Soil Management Specialist – Field Crops | Adam Hayes | Tel: (519) 674-1621 | adam.hayes@omafra.gov.on.ca |
| Pathologist – Field Crops Program Lead | Albert Tenuta | Tel: (519) 674-1617 | albert.tenuta@omafra.gov.on.ca |
| IPM Modelling Specialist | Heather Griffiths | Tel: (519) 674-1694 | heather.griffiths@omafra.gov.on.ca |
| Soil Management Specialist – Horticulture | Anne Verhallen | Tel: (519) 674-1614 | anne.verhallen@omafra.gov.on.ca |
| Vegetable Crops Specialist | Elaine Roddy | Tel: (519) 674-1616 | elaine.roddy@omafra.gov.on.ca |
| Vegetable Crops Specialist | Janice LeBoeuf | Tel: (519) 674-1699 | janice.leboeuf@omafra.gov.on.ca |
| Entomology, Field Crops Program Lead | Tracey Baute | Tel: (519) 674-1696 | tracey.baute@omafra.gov.on.ca |
| Simcoe Resource Centre<br>P.O. Box 587, Blueline Rd & Hwy #3<br>Simcoe, ON N3Y 4N5 | | General Tel: (519) 426-7120<br>Fax: (519) 428-1142 | |
| New Crop Development Specialist | Mike Columbus | Tel: (519) 426-4509 | mike.columbus@omafra.gov.on.ca |
| Berry Crop Specialist | Pam Fisher | Tel: (519) 426-2238 | pam.fisher@omafra.gov.on.ca |

## Appendix H.
## Ontario Ministry of Agriculture and Food Staff (Continued)

| Specialty | Staff | Phone/Fax | E-mail |
|---|---|---|---|
| Sprayer Application Technology Specialist | *Vacant | | |
| Ginseng and Medicinal Herbs Specialist | Jan Schooley | Tel: (519) 426-4323 | jan.schooley@omafra.gov.on.ca |
| Pome Fruit IPM Specialist (Acting) | Kathryn Carter | Tel: (519) 426-4322 | kathryn.carter@omafra.gov.on.ca |
| IPM Specialist – Specialty Crops | Denise Beaton | Tel: (519) 582-7220, ext. 263 | denise.beaton@omafra.gov.on.ca |
| Stratford Resource Centre<br>581 Huron St.<br>Stratford, ON N5A 5T8 | | General Tel: (519) 271-0280<br>Fax: (519) 273-5278 | |
| Alternate Production Systems Specialist | Brian Hall | Tel: (519) 271-0083 | brian.hall@omafra.gov.on.ca |
| Cereals Specialist | Peter Johnson | Tel: (519) 271-8180 | peter.johnson@omafra.gov.on.ca |
| Biosolids Specialist | Michael Payne | Tel: (519) 271-4496 | michael.payne@omafra.gov.on.ca |
| Soil Fertility Specialist | Keith Reid | Tel: (519) 271-9269 | keith.reid@omafra.gov.on.ca |
| Soybean Specialist | Horst Bohner | Tel: (519) 271-5858 | horst.bohner@omafra.gov.on.ca |
| Thunder Bay<br>335 Euclid Ave.,<br>Thunder Bay, ON P7E 6G6 | | General Tel: (807) 475-1373<br>Fax: (807) 475-1219 | |
| Research Coordinator Northwestern Ontario | Gordon Scheifele | Tel: (807) 475-1373 | gordon.scheifele@omafra.gov.on.ca |
| Vineland – HRIO, University of Guelph<br>Box 7000 4890 Victoria Ave. N<br>Vineland Station L0R 2E0 | | General Tel: (905) 562-4141<br>Fax: (905) 562-3413 | |
| Greenhouse Floriculture Specialist | Wayne Brown | Tel: (905) 562-4141, ext. 179 | wayne.brown@omafra.gov.on.ca |
| Greenhouse Floriculture IPM Specialist | Graeme Murphy | Tel: (905) 562-4141, ext. 106 | graeme.murphy@omafra.gov.on.ca |
| Vineland Resource Centre<br>Adv. Serv. Building, Box 8000, 4890 Victoria Ave.<br>North Vineland Station, ON L0R 2E0 | | General Tel: (905) 562-4147<br>Fax: (905) 562-5933 | |
| Tender Fruit and Grape Specialist | Ken Slingerland | Tel: (905) 562-1639 | ken.slingerland@omafra.gov.on.ca |
| Nutrient Management Horticulture Crops Program Lead | Donna Speranzini | Tel: (905) 562-1170 | donna.speranzini@omafra.gov.on.ca |
| Entomology, Horticulture Program Lead | Hannah Fraser | Tel: (905) 562-1674 | hannah.fraser@omafra.gov.on.ca |
| Fresh Market Quality Program Lead | Dr. Jennifer R. DeEll | Tel: (905) 562-1693 | jennifer.deell@omafra.gov.on.ca |
| Tender Fruit and Grape IPM Specialist | Neil Carter | Tel: (905) 562-3833 | neil.carter@omafra.gov.on.ca |
| Woodstock Resource Centre<br>Box 666, Hwy. #59 N<br>Woodstock, ON N4S 7Z5 | | General Tel: (519) 537-6621<br>Fax: (519) 539-5351 | |
| Nutrient Management Field Crops Program Lead | Christine Brown | Tel: (519) 537-8305 | christine.brown@omafra.gov.on.ca |
| Guelph OMAF<br>1 Stone Rd. W.<br>Guelph, ON N1G 4Y2 | | | |
| Director Crop Technology | Bill Ingratta | Tel: (519) 826-3151<br>Fax: (519) 826-3567 | bill.ingratta@omafra.gov.on.ca |
| Manager, Greenhouse, Agroforestry and Specialty Crops | Annette Anderson | Tel: (519) 826-3286<br>Fax: (519) 826-3567 | annette.anderson@omafra.gov.on.ca |
| Manager, Horticulture Technology | Hugh Berges | Tel: (519) 826-3288<br>Fax: (519) 826-3567 | hugh.berges@omafra.gov.on.ca |
| Manager, Horticulture Crops | John Finlay | Tel: (519) 826-6941<br>Fax: (519) 826-3567 | john.finlay@omafra.gov.on.ca |
| Manager, Field Crops | Brent Kennedy | Tel: (519) 826-3257<br>Fax: (519) 826-3567 | brent.kennedy@omafra.gov.on.ca |
| Marketing and Communications Officer | Cathy Wilson Pinkney | Tel: (519) 826-3150<br>Fax: 826-3259 | cathy.wilsonpinkney@omafra.gov.on.ca |
| Crop Protection Program Lead | Craig Hunter (on assignment) | Tel: (519) 826-4189<br>Fax: (519) 826-3259 | craig.hunter@omafra.gov.on.ca |
| Apiary Specialist | Doug McRory | Tel: (519) 826-3595<br>Fax: (519) 826-3567 | doug.mcrory@omafra.gov.on.ca |

## Appendix H.
## Ontario Ministry of Agriculture and Food Staff (Continued)

| Specialty | Staff | Phone/Fax | E-mail |
|---|---|---|---|
| Product Development Specialist | Kelly Ward | Tel: (519) 826-4094<br>Fax: (519) 826-4964 | kelly.ward@omafra.gov.on.ca |
| Vegetable Crops Specialist | Kristen Callow | Tel: (519) 826-4963<br>Fax: (519) 826-4964 | kristen.callow@omafra.gov.on.ca |
| On-Farm Food Safety Program Lead | Sandra Jones | Tel: (519) 826-3289<br>Fax: (519)826-4964 | |
| Applied Research Coordinator – Horticulture | *Vacant | | |
| Organic Crop Production Program Lead | Hugh Martin | Tel: (519) 826-4587<br>Fax: (519)826-4964 | hugh.martin@omafra.gov.on.ca |
| Minor Use Coordinator | Jim Chaput | Tel: (519) 826-3539<br>Fax: (519) 826-4964 | jim.chaput@omafra.gov.on.ca |
| Potato Specialist | Dr. Eugenia Banks | Tel: (519) 826-3678<br>Fax: (519) 826-4964 | eugenia.banks@omafra.gov.on.ca |
| University of Guelph<br>50 Stone Rd. E.<br>Guelph, ON N1G 2W1 | | General Tel: (519) 824-4120 | |
| Turfgrass Specialist<br>Guelph Turfgrass Institute<br>328 Victoria Rd. S., R.R. # 2<br>Guelph, ON N1H 6H8 | Pam Charbonneau | Tel: (519) 824-4120, ext. 2597<br>Fax: (519) 766-1704 | pamela.charbonneau@omafra.gov.on.ca |
| Pathologist – Horticulture Crops Program Lead<br>Edmund Bovey Building | Michael Celetti | Tel: (519) 824-4120, ext. 8910<br>Fax: (519) 767-0755 | michael.celetti@omafra.gov.on.ca |
| Nursery Crops Specialist<br>Edmund Bovey Building | Jennifer Llewellyn | Tel: (519) 824-4120, ext. 2671<br>Fax: (519) 767-0755 | jennifer.llewellyn@omafra.gov.on.ca |
| Nutrition – Horticulture Program Lead<br>Land Resource Science, Richards Building | Christoph Kessel | Tel: (519) 824-4120, ext. 2480<br>Fax: (519) 824-5730 | christoph.kessel@omafra.gov.on.ca |
| Weed Management Field Crops Program Lead<br>Crop Science Building | Mike Cowbrough | Tel: (519) 824-4120, ext. 2580<br>Fax: (519) 763-8933 | mike.cowbrough@omafra.gov.on.ca |
| Applied Research Coordinator – Field Crops<br>Crop Science Building | Ian McDonald | Tel: (519) 824-4120, ext. 6707<br>Fax: (519) 763-8933 | ian.mcdonald@omafra.gov.on.ca |
| Corn Industry Program Lead<br>Crop Science Building | Greg Stewart | Tel: (519) 824-4120, ext. 4865<br>Fax: (519) 763-8933 | greg.stewart@omafra.gov.on.ca |

## Agricultural Information Contact Centre

Provides province-wide, toll-free technical and business information to commercial farms, agri-businesses and rural businesses.

1 Stone Rd. W.
Guelph ON N1G 4Y2

General Tel: (877) 424-1300 or (519) 826-4047
Fax: (519) 826-7610
E-mail: ag.info@omafra.gov.on.ca

## Guelph – Government Information Centre

1 Stone Rd. W.
Guelph ON N1G 4Y2
Staff Directories — Phone 1-888-466-2372 or (519) 826-3100

## Appendix I.
## The Metric System

### Metric Units

**Linear Measures (length)**

| | | |
|---|---|---|
| 10 millimetres (mm) | = | 1 centimetre (cm) |
| 100 centimetres (cm) | = | 1 metre (m) |
| 1,000 metres | = | 1 kilometre (km) |

**Square Measures (area)**

| | | |
|---|---|---|
| 100 m X 100 m = 10,000 $m^2$ | = | 1 hectare (ha) |
| 100 ha | = | 1 square kilometre ($km^2$) |

**Cubic Measures (volume)**

***Dry Measure***

| | | |
|---|---|---|
| 1,000 cubic millimetres ($mm^3$) | = | 1 cubic centimetre ($cm^3$) |
| 1,000,000 $cm^3$ | = | 1 cubic metre ($m^3$) |

***Liquid Measure***

| | | |
|---|---|---|
| 1,000 millilitres (mL) | = | 1 litre (L) |
| 100 L | = | 1 hectolitre (hL) |

**Weight-Volume Equivalents (for water)**

| | | |
|---|---|---|
| (1.00 kg) 1,000 grams | = | 1 litre (1.00 L) |
| (0.50 kg) 500 g | = | 500 mL (0.50 L) |
| (0.10 kg) 100 g | = | 100 mL (0.10 L) |
| (0.01 kg) 10 g | = | 10 mL (0.01 L) |
| (0.001 kg) 1 g | = | 1 mL (0.001 L) |

**Weight Measures**

| | | |
|---|---|---|
| 1,000 milligrams (mg) | = | 1 gram (g) |
| 1,000 g | = | 1 kilogram (kg) |
| 1,000 kg | = | 1 tonne (t) |
| 1 mg/kg | = | 1 part per million (ppm) |

**Dry–Liquid Equivalents**

| | | |
|---|---|---|
| 1 $cm^3$ | = | 1 mL |
| 1 $m^3$ | = | 1,000 L |

***Calculating Parts per Million (ppm)***

| | | |
|---|---|---|
| 1 ppm | = | 1 g active ingredient per 1,000 L water |

***Handy Metric Conversion Factor***

| | | |
|---|---|---|
| litres per hectare x 0.4 | = | litres per acre |
| kilograms per hectare x 0.4 | = | kilograms per acre |

### Application Rate Conversions

**Metric to Imperial (Approximate)**

| | | |
|---|---|---|
| litres per hectare x 0.09 | = | gallons per acre |
| litres per hectare x 0.36 | = | quarts per acre |
| litres per hectare x 0.71 | = | pints per acre |
| millilitres per hectare x 0.015 | = | fluid ounces per acre |
| grams per hectare x 0.015 | = | ounces per acre |
| kilograms per hectare x 0.89 | = | pounds per acre |
| tonnes per hectare x 0.45 | = | tons per acre |

**Imperial to Metric (Approximate)**

| | | |
|---|---|---|
| gallons per acre x 11.23 | = | litres per hectare (L/ha) |
| quarts per acre x 2.8 | = | litres per hectare (L/ha) |
| pints per acre x 1.4 | = | litres per hectare (L/ha) |
| fluid ounces per acre x 70 | = | millilitres per hectare (mL/ha) |
| tons per acre x 2.24 | = | tonnes per hectare (t/ha) |
| pounds per acre x 1.12 | = | kilograms per hectare (kg/ha) |
| ounces per acre x 70 | = | grams per hectare (g/ha) |

**Liquid Equivalents**

| *Litres/Hectare* | | *Approximate Gallons/Acre* |
|---|---|---|
| 50 | = | 5 |
| 100 | = | 10 |
| 150 | = | 15 |
| 200 | = | 20 |
| 250 | = | 25 |
| 300 | = | 30 |

**Dry Weight Equivalents**

| *Grams or Kilograms / Hectare* | | *Ounces or Pounds /Acre* |
|---|---|---|
| 100 grams | = | 1½ ounces |
| 200 grams | = | 3 ounces |
| 300 grams | = | 4¼ ounces |
| 500 grams | = | 7 ounces |
| 700 grams | = | 10 ounces |
| 1.10 kilograms | = | 1 pound |
| 1.50 kilograms | = | 1¼ pounds |
| 2.00 kilograms | = | 1¾ pounds |
| 2.50 kilograms | = | 2¼ pounds |
| 3.25 kilograms | = | 3 pounds |
| 4.00 kilograms | = | 3½ pounds |
| 5.00 kilograms | = | 4½ pounds |
| 6.00 kilograms | = | 5¼ pounds |
| 7.50 kilograms | = | 6¾ pounds |
| 9.00 kilograms | = | 8 pounds |
| 11.00 kilograms | = | 10 pounds |
| 13.00 kilograms | = | 11½ pounds |
| 15.0 kilograms | = | 13½ pounds |

**Metric Conversions**

| | | |
|---|---|---|
| 5 mL | = | 1 tsp |
| 15 mL | = | 1 tbsp |
| 28.5 mL | = | 1 fl. oz |

## Conversion Tables — Metric to Imperial

### Length

1 millimetre (mm) = 0.04 inch
1 centimetre (cm) = 0.40 inch
1 metre (m) = 39.40 inches
1 metre (m) = 3.28 feet
1 metre (m) = 1.09 yards
1 kilometre (km) = 0.62 mile

### Area

1 square centimetre (cm$^2$) = 0.16 square inch
1 square metre (m$^2$) = 10.77 square feet
1 square metre (m$^{2)}$ = 1.20 square yards
1 square kilometre (km$^2$) = 0.39 square mile
1 hectare (ha) = 107,636 square feet
1 hectare (ha) = 2.5 acres

### Volume (dry)

1 cubic centimetre (cm$^3$) = 0.061 cubic inch
1 cubic metre (m$^3$) = 1.31 cubic yards
1 cubic metre (m$^3$) = 35.31 cubic feet
1,000 cubic metres (m$^3$) = 0.81 acre-foot
1 hectolitre (hL) = 2.8 bushels

### Volume (liquid)

1 millilitre (mL) = 0.035 fluid ounce
1 litre (L) = 1.76 pints
1 litre (L) = 0.88 quart
1 litre (L) = 0.22 gallon (Imp.)
1 litre (L) = 0.26 gallon (U.S.)

### Weight

1 gram (g) = 0.035 ounce
1 kilogram (kg) = 2.21 pounds
1 tonne (t) = 1.10 short tons
1 tonne (t) = 2,205 pounds

### Pressure

1 kilopascal (kPa) = 0.15 pounds/in$^2$

### Speed

1 metre per second = 3.28 feet per second
1 metre per second = 2.24 miles per hour
1 kilometre per hour = 0.62 mile per hour

### Temperature

°F = (°C X $^9/_5$) + 32

## Conversion Tables — Imperial to Metric

### Length

1 inch = 2.54 cm
1 foot = 0.30 m
1 yard = 0.91 m
1 mile = 1.61 km

### Area

1 square foot = 0.09 m$^2$
1 square yard = 0.84 m$^2$
1 acre = 0.40 ha

### Volume (dry)

1 cubic yard = 0.76 m$^3$
1 bushel = 36.37 L

### Volume (liquid)

1 fluid ounce (Imp.) = 28.41 mL
1 pint (Imp.) = 0.57 L
1 gallon (Imp.) = 4.55 L
1 gallon (U.S.) = 3.79 L

### Weight

1 ounce = 28.35 g
1 pound = 453.6 g
1 ton = 0.91 tonne

### Pressure

1 pound per square inch = 6.90 kPa

### Temperature

°C = (°F – 32) x $^5/_9$

## Abbreviations

% = per cent (by weight)
ai = active ingredient
AP = agricultural powder
cm = centimetre
cm$^2$ = square centimetre
DG = dispersible granular
DP = dispersible powder
E = emulsifiable
e. g. = for example
EC = emulsifiable concentrate
F = flowable
g = gram
Gr = granules, granular
ha = hectare
kg = kilogram
km = kilometre
km/h = kilometres per hour
kPa = kilopascal
L = litre
m = metre
m$^2$ = square metre
mL = millilitre
mm = millimetre
m/s = metres per second
SC = sprayable concentrate
SP = soluble powder
t = tonne
W = wettable (powder)
WDG = water dispersible granular
WP = wettable powder

# Emergency and First-Aid Procedures for Pesticide Poisoning

For a major spill, a theft or a fire involving a pesticide call the Ministry of the Environment at **1-800-268-6060.**

For pesticide poisonings and pesticide injuries call the Poison Information Centre:

| | |
|---|---|
| Toronto | 1-800-268-9017 |
| Ottawa (Bilingual) | 1-800-267-1373 |
| Hearing Assistance (TTY) | 1-877-750-2233 |

## PREVENT ACCIDENTS

- **Read the label**. Follow all the precautions the label recommends. Read the First Aid section of the label BEFORE you begin to handle any pesticide.
- **Make sure that someone knows** what pesticides you are working with and where you are.
- **Keep a file of labels and product Material Safety Data Sheets (MSDS) for the pesticides you use**. Make sure everyone knows where to find this in case of an emergency.
- **Post emergency numbers near all telephones.**
- **Keep clean water, paper towels, extra gloves and clean coveralls close by** in case you spill pesticide on yourself.

**If someone has been working with pesticides and you see any possible symptoms of pesticide poisoning or injury, take emergency action immediately.**

### IF AN ACCIDENT OR POISONING HAPPENS

- Protect yourself from injury first.
- Stop the exposure to the pesticide. Move the victim away from the contaminated area.
- Check the 4 basic facts — identify the pesticide, the quantity, the route of entry and time of exposure.
- Call an ambulance or the Poison Information Centre.
- Start first aid. This is not a substitute for professional medical help.
- **Provide the label, MSDS sheet or container to emergency personnel** at the scene — or take it with you to the hospital. Do not transport pesticide containers in the passenger compartment of the vehicle.

## FIRST AID

**If a pesticide comes in contact with skin:**

- remove all contaminated clothing: wash skin thoroughly with lots of soap and warm water
- dry skin well and cover with clean clothing or other clean material.

**If pesticide comes in contact with eyes:**

- hold eyelids open wash the eyes with clean running water for 15 minutes or more.

**If pesticide was inhaled:**

- move the victim to fresh air and loosen tight clothing
- give artificial respiration if the victim is not breathing.

**Do not breathe in the exhaled air from the victim — you could also be poisoned.**

**If a pesticide was swallowed:**

- **call the Poison Information Centre IMMEDIATELY.**

**Emergency numbers are listed at the front of each Bell telephone directory.**

For information, or to obtain copies of this or any other ministry publication please: call 1-888-466-2372 from within Ontario. (519) 826-3700 from outside the province or OMAF's TTY line at (519) 826-7402 for the hearing impaired. email your request to *products@omafra.gov.on.ca*. or visit OMAF's Web site at *www.gov.on.ca/omaf*.

A complete list of all OMAF products and services, and order forms, are available on the Web site. Orders can be faxed to (519) 826-3633 or mailed to Government Information Centre, OMAF, 1 Stone Road West, Guelph, Ontario N1G 4Y2.

Published by the Ministry of Agriculture and Food
© Queen's Printer for Ontario 2002
Toronto, Canada

ISSN 0701-5348 RV 04-02-5M